This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

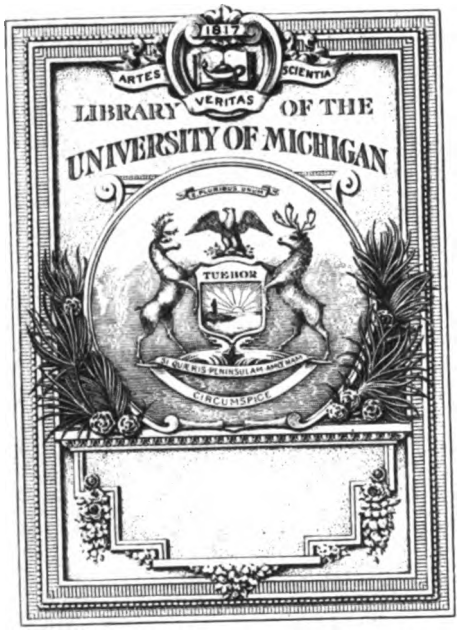
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Transactions of the American Microscopical Society

American Microscopical Society, JSTOR (Organization)

Digitized by Google



Digitized by Google

QH
201
.A52

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

TRANSACTIONS

OF THE

American Microscopical Society

ORGANIZED 1878 INCORPORATED 1891

EDITED BY THE SECRETARY

Twenty-First Annual Meeting

HELD AT

SYRACUSE, NEW YORK, AUGUST 30, 31 AND SEPTEMBER 1, 1898

VOLUME XX

LINCOLN, NEB.
HUNTER PRINTING COMPANY
1899

Digitized by Google

QH
201
.A52

OFFICERS FOR 1898-9.

President: WILLIAM C. KRAUSS, M. D., F. R. M. S. . . . Buffalo, N. Y.
Vice Presidents: G. CARL HUBER, M. D., F. R. M. S . . Ann Arbor, Mich.
A. M. BLEILE, M. D. . . . . Columbus, O.
Secretary: HENRY B. WARD, A. M., PH. D. . . . . Lincoln, Nebr.
Treasurer: MAGNUS PFLAUM . . . . . Pittsburgh, Pa.

ELECTIVE MEMBERS OF THE EXECUTIVE COMMITTEE.

SIMON H. GAGE, B. S. . . . . Ithaca, N. Y.
A. CLIFFORD MERCER, M. D., F. R. M. S. . . . . Syracuse, N. Y.
VERANUS A. MOORE, M. D. . . . . Ithaca, N. Y.

PAST PRESIDENTS.

Ex-officiis members of the Executive Board.

1. R. H. WARD, M. D., F. R. M. S., of Troy, N. Y., at Indianapolis, Ind., 1878
2. R. H. WARD, M. D., F. R. M. S., of Troy, N. Y., at Buffalo, N. Y., 1879
3. H. L. SMITH, LL. D., F. R. M. S., of Geneva, N. Y., at Detroit, Mich., 1880
4. J. D. HYATT, F. R. M. S., of New York City, at Columbus, O., 1881
5. GEO. E. BLACKHAM, M. D., F. R. M. S., of Dunkirk, N. Y., at Elmira, N. Y., 1882
6. ALBERT MCCALLA, PH. D., F. R. M. S., of Fairfield, Ia., at Chicago, Ill., 1883
7. J. D. COX, LL. D., F. R. M. S., of Cincinnati, O., at Rochester, N. Y., 1884
8. H. L. SMITH, LL. D., F. R. M. S., of Geneva, N. Y., at Cleveland, O., 1885
9. T. J. BURRILL, PH. D., F. R. M. S., of Champaign, Ill., at Chautauqua, N. Y., 1886
10. WM. A. ROGERS, LL. D., F. R. M. S., of Waterville, Me., at Pittsburg, Pa., 1887
11. D. S. KELLICOTT, PH. D., F. R. M. S., of Columbus, O., at Columbus, O., 1888
12. WM. J. LEWIS, M. D., F. R. M. S., of Hartford, Conn., at Buffalo, N. Y., 1889
13. GEO. E. FELL, M. D., F. R. M. S., of Buffalo, N. Y., at Detroit, Mich., 1890
14. FRANK L. JAMES, PH. D., M. D., F. R. M. S., of St. Louis, Mo., at Washington, D. C., 1891
15. MARSHALL D. EWELL, M. D., F. R. M. S., of Chicago, Ill., at Rochester, N. Y., 1892
16. JACOB D. COX, LL. D., F. R. M. S., of Cincinnati, O., at Madison, Wis., 1893
17. LESTER CURTIS, M. D., F. R. M. S., of Chicago, Ill., at Brooklyn, N. Y., 1894
18. SIMON HENRY GAGE, B. S., of Ithaca, N. Y., at Ithaca, N. Y., 1895
19. A. CLIFFORD MERCER, M. D., F. R. M. S., of Syracuse, N. Y., at Pittsburg, Pa., 1896
20. E. W. CLAYPOLE, D. SC. (Lond.), F. G. SS. L. E. & A., of Akron, O., at Toledo, O., 1897
21. D. S. KELLICOTT, PH. D., F. R. M. S., of Columbus, O., at Syracuse, N. Y., 1898

The Society does not hold itself responsible for the opinions expressed by members in its published Proceedings unless indorsed by a special vote.

Digitized by Google

Eigenmann

QH
201
.A52

ORGANIZED 1878 INCORPORATED 1891

MAY, 1899

TRANSACTIONS OF THE AMERICAN MICROSCOPICAL SOCIETY

EDITED BY THE SECRETARY

TWENTY-FIRST ANNUAL MEETING
HELD AT
SYRACUSE, NEW YORK,
AUGUST 30, 31, AND SEPTEMBER 1, 1898

VOLUME XX

Digitized by Google

CONTENTS OF VOLUME XX.

	PAGE
Officers and Executive Committee for 1898–9	2
The Annual Address of the Presiding Officer, The Natural in Disease, Veranus A. Moore	3
David Simons Kellicott, Obituary Notice by A. M. Bleile	21
William A. Rogers, Obituary Notice by S. H. Gage	25
Henry C. Coons, Obituary Notice by S. H. Gage	28
Special Structural Features in the Air-sacs of Birds, Mary J. Ross	29
Micrometry of the Human Red Blood Corpuscle, Frank Judson Parker	41
The Regeneration of the Intestinal Epithelium in the Toad (*Bufo lentiginosus americanus*) during Transformation, B. F. Kingsbury	45
Method for Preparing Nucleated Blood in Bulk for Class Demonstration, T. E. Oertel	49
Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana, J. C. Smith	51
The Persistence of Bacteria in the Milk Ducts of the Cow's Udder, Archibald R. Ward	57
An Occurrence of Albino Eggs of the Spotted Salamander, *Amblystoma punctatum* L., Horace W. Britcher	69
Experiments in Feeding Some Insects with Cultures of Comma or Cholera Bacilli, R. L. Maddox	74
Questions in Regard to the Diphtheria Bacillus, M. A. Veeder	81
Medical Microscopy, A. A. Young	87
Agar-Agar, W. W. Alleger	81
Contributions to the Histogenesis of the Caryophyllales. I., Frederic E. Clements	97
Carcinoma on the Floor of the Pelvis, Two Discoveries in Cancerous Disease, Mary A. Dixon Jones	165
Effect of High Altitude on Blood Counts, A. Mansfield Holmes	177
Photo-micrography with Opaque Objects, W. H. Walmsley	189
On the North American Species of the Genus Atax (Fabr.) Bruz, Robert H. Wolcott	193
Freshwater Investigations during the Last Five Years, Henry B. Ward.	261
Picro-carmine and Alum Carmine as Counter Stains, B. D. Myers	337
A Rapid Staining Apparatus, C. M. Mix	341
Minutes of the Annual Meeting	347
Treasurer's Report	353
Constitution	355
By-Laws	356
List of Members	358
Biennial Index to Volumes XIX and XX	365

Digitized by Google

General library
11-27-39

PROCEEDINGS

OF

The American Microscopical Society

TWENTY-FIRST ANNUAL MEETING, HELD AT SYRACUSE, NEW YORK, AUGUST 30, 31 AND SEPTEMBER 1, 1898.

THE ANNUAL ADDRESS OF THE PRESIDING OFFICER.*

THE NATURAL IN DISEASE.

VERANUS A. MOORE, ITHACA, N. Y.

It is specified in the constitution of this society, that the president shall deliver an address at its annual meeting. In the past, these have consisted of a presentation of the results of personal investigation, a resume of the present knowledge of the particular subject in which the speaker happened to be most interested, or, a more philosophic dissertation on some phase of micro-biology. The most arduous of the duties of the president seems to have become the preparation of such a treatise, and its reception the special enjoyment of these annual gatherings. This year, however, there has happened a sad incident which has marred the pleasure of this meeting, and which has snatched from us the president's annual offering.

In the death of President Kellicott, this society has lost one of its early members and a loyal friend, and the world a most

*The sudden death of President Kellicott in April last, and the impaired health of the first vice president, caused, for the first time in the history of the society, the duties of the presiding officer to fall upon the second vice president.

Digitized by Google

enthusiastic student of natural history. He was a man whose life was spent in nature's great laboratory, and if he had been spared to address us on this occasion, we would have listened to an important chapter from nature study. He taught during his lifetime the existence of higher and nobler ideals. Personally, I am much indebted to the living influence of his forceful character and, if perchance, in my feebleness in trying to do as he would have wished, I shall be so fortunate as to kindle anew or deepen your interest in pure or applied biology, cherish the thought as a reflected message from him who would, had God willed, instructed us this hour.

Under the trying circumstances, I had some difficulty in selecting a topic for this formal address. The little time since this unexpected duty fell to me has been so overcrowded with other and more imperative duties, that it was impossible to carry out a new, or even complete, any line of investigation, the results of which could be used on this occasion. Likewise it was too brief for preparing a discussion on any of the broader and more fundamental problems centered in any of the sciences represented in our society. It so happened, however, that following this call to duty, I had occasion to adjust a course of instruction in comparative bacteriology, to meet the needs of students of human medicine, and, at the same time, to fill it full for those who were seeking knowledge in comparative pathology. In working out this actual and seemingly difficult problem, the subject as announced suggested itself and in its somewhat popular consideration I ask your indulgence.

If, in my selection, I seem to have failed in appreciating the fitness of things, and to have brought before a society which deals in pure science, a jungle of practical "isms", I must ask, impertinent as it may seem, what is the aim, the ultimate purpose, of the observations and rich discoveries in physiology, in in anatomy, in botany, and to a less extent in pathology as carefully recorded in our annual volumes? Why have so many workers in biology striven with untiring energy to discover the hidden structure or to learn the vital purpose of the cells of the living body, not only in man but in the lowlier animals and in

Digitized by Google

plants as well. The technical and enthusiastic biologist sometimes hesitates when he is asked to point out the practical significance of his investigations; but, the sober answer of the devotee of each of the varied branches of human research assures us that it is for bettering human existence. How this is to be brought about, is in the beginning unthought of, but we all share in the consciousness that the discovery of a new fact, the crystalizing of a new truth, the extending of our horizon into nature's processes by a single ray, adds something to the sum total of human enjoyment.

Undoubtedly, the primary purpose of this organization was to hasten the perfection and application of the microscope. This instrument which has passed through a most perfect evolution, rising from a simple lens beset with errors in contour, to a complicated instrument, not only for magnification but of precision as well. By its aid, the ultimate cells in the structure of the organic world are being measured and delineated with mathematical exactness. However, time has shown, that equally as important a result issuing from this band of workers has been a share in the elucidation of many obscure problems in the realm of natural history. Although in themselves they are seemingly remote from the ideals of the utilitarian, they have little by little illuminated the conditions connecting the normal with the abnormal until many of the cords which bound pain and suffering to mankind have snapped asunder.

There is, perhaps, nothing in the evolution of human thought which stands out more conspicuously than the idea of the supernatural in producing and curing disease. In Egypt, in India, in Persia and in China, the healing art was entrusted to the priestly class. In the middle centuries the faith in the supernatural cause of disease and belief in fetish cures became so strong, that there was something irreligious in seeking cure by natural means. At one time it is affirmed that physicians were forbidden to treat the sick without calling in ecclesiastical advice. As a rule, the leaders in theology discouraged the belief that diseases were caused by natural agencies. It is largely due to this, that it was possible for the vast system of "pas-

Digitized by Google

toral medicine'' so powerful in the middle ages, and in certain phases continuing even at the present time to exist. Monasteries possessed healing relics which turned vast treasures into their coffers. The skulls of the three wise men of the East so carefull encased in the cathedral of Cologne, and the bones from plundered cemeteries hung on the walls of the churches of St. Gereon and of St. Ursula are said to have been potent agencies in healing the sick and remunerating the priests. Even Martin Luther, the great champion of religious liberty, ascribed his own diseases to "Devil's spells", and declared that "Satan produces all the maladies which afflict mankind".

In opposition to the idea of the supernatural as the immediate and specific cause of disease, there sprang up with the teachings of Hippocrates, a different and more rational theory. Living as he did in that early age of lofty thought and philosophy, he broke away from the traditional theories and laid the foundations of medical science upon experience, observation and reason. The school of Alexandria promulgated this theory. Thus five hundred years before the Christian Era, the minds of a few men were turned toward the natural in disease; but the little which had been gained seemed to have been lost in the middle ages with the development of the new interpretation of disease as a product of satanic forces, and the restoration to health the special act of a Divine agency.

For nearly two thousand years after Hippocrates, the condition of the science and of the art of medicine was primitive indeed. Like those poor people of to-day who try to charm away disease with a "madstone", the sick and injured were the victims of circumstances, or, rather, they lived or died as the chance may have been. We sometimes forget that many people in the present generation entertain vagaries concerning the cause of physical disorders which are quite as astonishing as those cherished more generally centuries ago. The time seems to be ripe when biology should claim the abnormal and its causes as a complement to the normal. Do we not find in the abnormal as elsewhere, that "Nature is neither kind nor cruel, but simply obedient to law, and, therefore, consistent"! The

Digitized by Google

burden of the thought which led to the selection of my subject, was the vast indebtedness of the world to biology for interpreting the nature and finding the cause of so many of the diseases which afflict the vegetable and animal kingdoms. To this should be added the desire of every honest physician and every thoughtful teacher of biology to have all who will feel that disease is a natural product, that its coming and its going depend largely upon conditions which are possible for man to find out and control. I do not wish to be understood by this that it is within man's power to prolong life indefinitely, but rather, that those maladies which shorten our allotted three score years and ten upon earth, are, for the greater part, preventable.

The early history of medicine is confined in the biography of a few men. Schools were founded on men, not on principles until the increeping of error and false hypotheses became more potent than truth itself. But worse than this, and more to be regretted than all the other undesirable influences of those early teachings, there grew up in the public mind that greatest of misconceptions, the belief in disease as an entity, "an evil spirit to be exorcised and driven out by drugs". The superficial observer recognizes only results, he is content with knowing the end, never seeking the causes. Results are his ultimatum, for factors and forces have not disturbed the quietude of his mental processes.

As we approach the early dawn of modern medicine, we find Sydenham going to nature for an explanation of the morbid processes which confront the practitioner. He laid down and acted upon the fundamental proposition that, "All diseases should be described as objects of natural history". In discussing the method for the study of medicine, he states, "In writing, therefore, such a natural history of diseases, every merely philosophical hypothesis should be set aside, and the manifest and natural phenomena, however minute, should be noted with the utmost exactness". His theories were rigorously opposed by Morton and others who considered all diseases to be "poisoning of the vital spirits", but he became the standard bearer of his time in returning to the methods of Hippocrates whose

Digitized by Google

method and art of healing "were founded on the nature of things, and on the limits of human ability".

Among those who were foremost in subduing prejudices and eliminating false hypotheses which smothered the study of disease for so many centuries, should be mentioned John Hunter. He may be known to some of us better as naturalist than physician. It is, perhaps, through his great achievements as student of nature, that he exercised his greatest power. He was a pathologist, but he looked upon morbid processes as a part of the great whole, governed by law, but which could not be understood until the facts were secured, tabulated and systematized. His untiring industry and peculiarily interesting experiments, attracted men to him, and it has been well said that, "he made all physicians naturalists". Certain it was, that in his generation and that immediately following him, many of the successful practitioners became distinguished as students of nature.

If we should trace from the beginning the progress in human pathology, we would find that the great landmarks are the discoveries and the works of biologically trained men who were devotees of pure science, and not the results of those who made technical utility their guiding principle. What would modern medicine and surgery be if we should strip from them all of these useful and beneficient applications which have come from the discoveries of Galvani, Volta, Harvey, Priestly, Magendie, Claude Bernard and many others, to say nothing of the wonderful revelations which have been made in more recent years? The revolution in surgery wrought by Lister has its origin in the discoveries made by Pasteur, a chemist and biologist. It is an interesting fact, that those medical schools which have advanced the science of medicine most, have been associated with great Universities which offered special inducements for biologic study. While there has existed on the one hand a feeling that the science of medicine is something more enobling than a part of pure biology, and on the other, the technical botanist and zoologist sometimes frown upon the seeming looseness of the science of the healing art, there is much in old asso-

Digitized by Google

ciations to increase a mutual sympathy. Before there was a school of botany or zoology, or of law, or even of theology, there was a school of medicine. For centuries, all there was of biology was clustered around the teachers of medicine, many of whom advanced our knowledge of disease with most astonishing rapidity by means of their discoveries as biologists. Pathology itself which is the pure science of medicine as contrasted with the healing art, was without a name even, until a better knowledge of the normal revealed the existence here and there of the abnormal. These deformities were relegated to a department by themselves where they remained undisturbed until finally they attracted the attention of a few zealous students of nature, who, in the course of time, have shown that the abnormal holds an equal position with the normal in the great group of Natural Sciences.

It would be interesting to continue this retrospect and learn how perfectly the premises, that "disease is a part of natural history", as it is now understood, was heralded by those fathers of modern medicine who saw deeper into the nature of the abnormal than the average man. However, the brilliancy of those early prophecies, those beacon lights of the new pathology, no matter how bright they might have been, are as shadows compared with the actual that has happened in the evolution of pathology. It is exceedingly modest to affirm that the investigations and experiments which have been made during the last fifty years have done more than all the observations of the preceding centuries to raise pathology from the realm of superstition and darkness, to conditions of light and exactness. Illustrations are numerous, but perhaps the specific diseases offer the most striking ones. From the very dawn of medical history to the brilliant investigations of Davaine, published in 1863, anthrax had decimated again and again the flocks and shepherds of the civilized world. Its nature was unknown, its cause was shrouded in mystery, and its coming was supposed to be an expression of rebuke from angry gods or enraged devils. Since 1863 the specific cause of ths disease has been discovered, and its terrors have been allayed by prohibiting its appearance.

Digitized by Google

Tuberculosis, Asiatic cholera, and the pest of India, afford similar illustrations of human vagueness in the past concerning the nature of disease and the feeble faith in man's ability to prevent or control them. We are no longer paralyzed by fear of epidemics of these terrible diseases for their causes have been captured and brought largely within the control of man, and today these specific agents are growing, somewhat as curiosities, in peaceful colonies in scores of our biologic laboratories. Where in the history of man's advancement can greater victories be found?

Definite knowledge which led to the demonstration of morbid processes, as products of natural agencies, began to accumulate with increased rapidity, near the dawn of the present century. In fact, this new theory took a definite position just as soon as biologists, physicists, and the makers of instruments of precision made it possible for the pathologist to study intelligently the finer structure of the abnormal. The progress of pathology has been paralleled with the progress of philosophy itself, "system succeeding system in genetic order." It was impossible, therefore, from the very nature of things, to have established a theory respecting the etiology of disease based upon natural or specific causes, so long as the reasoning and the philosophy of the day did not admit such a cause to be necessary. What could a rational interpreter of diseases do when the scientists advocated and the populace believed, not only in the possibility of, but in the actual every day happening of spontaneous generation? With the fall of that theory, micro-biology gained its first great victory, and cleared forever the passage to the rational study of the natural forces which ever exert themselves in the production and in the elimination of disease.

There is a tendency to look upon the infectious maladies as the only ones in which purely biologic agencies constitute the causal factors. To be sure, they furnish our most telling illustrations, and offer many inducements for consideration. However, I wish to call attention to a more neglected and perhaps, obscure topic in illustrating the natural in disease, namely, general pathology. While the epidemic diseases are serious

Digitized by Google

indeed, with their present subjugation they do not furnish the most of our physical troubles. Yet the statement which has become almost axiomatic, that "all of the common ailments are due to the violation of physical law", is believed in only a half hearted manner. There was much wisdom shown in the physician's reply to a patient complaining from a mixture of preventable disorders, "My dear sir, you have no business to be sick". The cellular pathology of Virchow, with its various modifications, has done an immeasureable amount of good in establishing the almost imperceptible gradation existing between health and disease.

The student of general pathology soon finds that, while many conditions of the abnormal have been differentiated from the general, by finding definite specific causes for them, much remains for interpretation. In fact, the unsolved problems in general pathology are so difficult that they seem to be intangible, so intimately do they come into relation with cosmic physics, meterology, geology, sociology, chemistry, botany, zoology, and the rest that a distinguished pathologist wrote "General pathology knows no other direction, and no other order than physiology". Illustrations of this are numerous. The highly developed biceps of the blacksmith, if submitted *per se* to the pathologist, would be called a beautiful specimen of hypertrophy, but the physiologist knowing the history, sees an illustration of high development from special use. The muscle of the hypertrophied heart brought on by over-exertion, caused by some valvular or other lesion, becomes a much more serious matter. It has been shown and the fact verified by members of this Society, how active and efficient the phagocytes are in eliminating foreign particles, like bits of carbon, from the body. Pathologists have pointed out the efficiency of these same cells in defending the body against foreign invaders. In both cases, however, they are sometimes overpowered, the infection is accomplished, the abscess is formed, the disease is established, and the life may be extinguished.

It must be admitted by us all that we are too prone to overlook the influences of environment. Are we not too willing to

Digitized by Google

pass over the action of natural forces and agencies, which either consciously or unconsciously have an indwelling influence upon the vital powers of the human or the animal body? To be sure, nature has furnished us with the benefit of certain adaptations of the abnormal, but these will not suffice to sustain the body under prolonged neglect. If there is physical or mental disability, there must be a cause. If there is vigor and intellectual superiority, there is somewhere in the cosmos an explanation. Henry Clay was called a crank because he always sent the hay and grain for his trotting horses from his own farm. When questions concerning this seemingly foolish notion he replied, "When my horses eat the hay and grain from my farm, they always win, when they do not, they always lose". This was called a whim, for neither Clay nor any one else could venture a rational explanation for the fact in the statement. Finally, however, it has been found that the forage and cereals of his locality in Kentucky contain 10 per cent and upwards more phosphoric acid than those from the localities where his horses competed. If this was an isolated case, it might still be doubted that the constituents of the soil and consequently of the forage had an influence upon the vital powers of the horse. It is a verified fact, however, that those particular localities noted for raising fine animals have a forage exceedingly rich in phosphates. Again, in the early days when at least the common people lived very largely upon the crops raised on the home farm, and before there was such an interchange of food products, it is interesting to note that the localities famous for raising fine horses were equally as conspicuous for their great men. If we read carefully geographical pathology, we find in certain districts a prevalence of certain physical disabilities which as yet, fall naturally into the general group, but which nevertheless have their origin in the influence of certain local conditions.

From a study of the more general conditions which influence the animal body, one is sometimes led to feel that there is a tendency to expect too much of the microscope and to neglect naked eye observations. The old time naturalist knew little of

Digitized by Google

minute anatomy, yet we could better spare much of the microscopic than the results of the close observations of Linneus, Hunter or Agassiz. The laboratory worker loses much that the field observer takes into account. So in general pathology he who studies the abnormal in itself, fails to discover its relation to natural forces and consequently the legitimate right for its existence. Hunter and Paget showed for the first that disease begins with slight deviations from the normal, and the real cause for these deviations may be as far from the generally accepted ones as was phosphoric acid from the mind of the jockey who rode Clay's horses.

It sometimes seems unfortunate that more of our biologists do not grapple with the problems in general pathology, and circumscribe with more definite observations and experiments, the conditions which lead to the abnormal. The agencies by way of instruments and reagents are more numerous and efficient than ever before. The knowledge of physiology and physiologic chemistry is constantly increasing and the topics which need more light seem inviting. As they pertain to the living tissues, they must be approached by those who feel an inspiration for the living. The solution of the problems concerning the theories of cell-proliferation set forth by Virchow and by Weigert would be ample to fill a life time of untiring research and experiment.

No doubt, one of the great difficulties is the inability to secure sufficient material. The naturalist preserves with equal care hundreds of duplicates of the specimen which he is to study. Is this so with the physicians who are the reapers for the pathologists, and in this connection for the biologists? Are they as careful as they might be in securing the important, not necessarily the rare, specimens which from time to time fall in their way? While it is true, that the study of pathology is best carried on in connection with a large hospital service, it is equally true that much highly important and valuable material never comes to the general ward. Who has followed the voluminous literature on the cause of malignant tumors without feeling that it is quite as important to continue their study as it has been in

Digitized by Google

the past? If we are to learn more concerning the cause and nature of these abnormalities, we must continue their study. Every examination carefully made brings out new facts, or prepares better than before the examiner for the next specimen. We are told that "To him who hath, shall be given", and certainly in the material world, this applies to none better than to the devotee of the science or of the art of medicine. A distinguished oculist had successfully removed a very bad cataract and was receiving the congratulations of a brother oculist who was deeply impressed with the skill and success of the operation. "Yes", was the reply, "but that operation has cost a bushel of eyes". This tells the story of success in explaining the cause of disease quite as much as in the art of healing.

The standing difficulty in pathology has been in the relations existing between morbid anatomy and etiology. The researches of Virchow, Conheim, Stricker, and others, have shown that wherever in the body there exists an abnormal aggregation of tissue it came from pre-existing cells. Upon the cause of their proliferation, there are different theories, but concerning the fundamental biologic principles involved, all are agreed. The infectious diseases were carefully described, their periods of incubation, symptoms and gross morbid anatomy were known to the older pathologists, but they failed to distinguish the cause. The reason may be found in the trend of the biologic thought and philosophy of the day, which precluded the need of natural, or specific agencies. For this reason, the natural forces which existed as the causal factors in the epidemics or plagues of the times could not be found.

With the development of the science of bacteriology, there came a new epoch in the human understanding of the nature of diseases, especially of the infectious ones. We are prone to look upon this new science as being exceedingly modern. In its present accepted meaning this may be true, but he who finds his way through the vast literature on the subject learns that its first paper was entitled, "The world of the infinitely little", written at Delft, Holland, by Anthony Von Leeuwenhoeck in 1675. It was this man's work which was done largely for

Digitized by Google

amusement, that laid the foundation of bacteriology, a science which is now recognized as having much to do with the organic world from the lowliest of plants to the highest of the animal kingdom. For two hundred years this science was kept alive by a few workers in succeeding generations. So mysterious did it seem, that naturalists could not comprehend the effect of the labors of these infinitely little structures. But finally methods and instruments were in hand with which it was possible to isolate and study the properties of individual species among them. As soon as this came, we read in rapid succession of the discovery of the specific causes, the species of bacteria which produce relapsing fever, traumatic infections, anthrax, tuberculosis, Asiatic cholera, typhoid fever, glanders, diphtheria, and many other pests of the animal kingdom. In addition to affording us this specific information, bacteriology has had a broadening influence on the general study of disease. It has taught a perpetual co-existence and vital interdependence of plants and animals, and in some instances established a unity in the etiology of the afflictions of man and of beasts. It has also taught us that these microscopic organisms which are largely our friends, but in part our enemies, stand in a similar relationship to the flowering plants. While they in the main, prepare the food for higher vegetation, a few species among them cause the most serious of plant diseases. Thus the pear blight, a destructive disease of melons, tomatoes, potatoes, cabbage, beets, sweet corn, and of the beautiful carnation are known to be caused by certain species of bacteria.

Indirectly, bacteriology has illuminated the significance of certain phases of zoology. The student of pathology, failing to find the specific cause of certain of the infectious diseases by means of the methods of the bacteriologist, modified them somewhat, and as a result, certain higher orders of plant life and a few protozoa became distinguished as the *agens morbi* in such affections as thrush, actinomycosis, malaria, Texas or Southern cattle fever, entero-hepatitis in turkeys and a serious form of dysentery in man.

These bacteria and protozoa which sometimes become para-

Digitized by Google

sitic on the animal body are being studied, as have been studied the birds of the air, the fishes of the deep, or the beasts of the earth. These organisms of the unseen world, unknown save through the adventitious agency of the microscope, give us one of the key notes of our temporal welfare: explain to us how it is that we are able to enjoy our existence, and proclaim to us that they, these same organisms, give us permission to live. Were it not for the saprophytic bacteria, "the world would be piled mountain high with the corpses of the past dead". Their usefulness permits our living. They serve to carry back to primeval elements all our composite organisms and organizations. The deduction of Pasteur in this connection are worthy of repetition, "That wherever and whenever there is decomposition of organic matter, whether it be the case of an herb, or of an oak, of a worm or of a whale, the work is exclusively done by infinitely small organisms. They are the important, almost the only agents of universal hygiene; they clear away more quickly than the dogs of Constantinople, or the wild beasts of the desert, the remains of all that has had life; they protect the living from the dead; they do more, if there are still living beings; if, since the hundreds of centuries the world has been inhabited, life continues, it is to them we owe it".

With the knowledge brought to us by bacteriology, the progress in the study of the specific causes of disease has been rapid. Further than this, the study of the influences of these causes upon the body generally has tended to explain much that remained mysterious in general pathology. In a very few years, etiology has united all of the biologic and physical sciences and brought them within the range of the student of medicine. Etiology has become permanently linked to microbiology. We look now to botany and to zoology for the exciting causes of the infectious diseases. If we still have difficulty in understanding the nature of these maladies, let us view them in the light of parasitism. The sufferer from malaria, tuberculosis or anthrax is actually a host entertaining, at the expense of his own vital forces, a multitude of ungrateful guests in the form of microscopic plants or animals.

Digitized by Google

If we look up and down the scale of the animal and vegetable kingdoms we recognize over and over again the destructive tendencies of the living upon the living. Sometimes the scene becomes tragical as witnessed in the jungles or in the trackless deep. Sometimes the struggle is long continued and we watch for the outcome, feeling sure that without the intervention of forces guided by the intellect, the combatant which best adapts itself to the environment will eventually win. Sometimes we see the little parasitic vine slowly entwine itself about a powerful tree, drawing its substance from it until finally the life of the tree goes out. In the reservoirs of India, Koch found the water swarming with little organisms which, when taken into the human body, multiplied and gave rise to a series of symtoms and tissue changes which prostrated their host and which condition has long been known as Asiatic cholera. All of the infectious diseases, whether caused by bacteria, higher fungi or protozoa, afford illustrations of the simplest organisms becoming parasitic upon the more highly organized plants or animals. Thus it has come about that the abnormal which is seen so often in nature sometimes restricted to single individuals, sometimes appearing as devastating plagues, has been demonstrated to be the result of natural forces acting under changed conditions. The prophesies by way of the theories of Hippocrates, Sydenham and Hunter, have been fulfilled in the results of investigations carried out since the organization of this society.

If the discovery of the cause foretold the end, we could feel that, so far as the infectious diseases are concerned, the goal is near at hand. But such is not the case. Pathologists are being led step by step into broader and infinitely more complicated fields. Preventive medicine, which is the key note of modern medicine, is clamoring for more definite, specific knowledge concerning the possibilities of not only recognized pathogenic bacteria, but of others as well. Health officers are asking for information concerning the possible means of infection, and epidemics and epizootics of peculiar character are constantly appearing and demand interpretation. Then come

Digitized by Google

the numerous questions concerning the relationship and identity of certain animal and human diseases. Comparative and experimental pathology, which have become a necessity in the interpretation of certain human affections, have laid at our door a series of problems, so long and so difficult, that the most hopeful read the subjects of research for generations to come. Every practical investigation in comparative pathology brings to light a host of problems, perhaps of secondary importance, but clamoring for attention.

I have already referred to the significance of etiology. I desire to call attention to a few important illustrative results in comparative etiology. In an old pathology we learn that formerly tuberculosis, glanders and actinomycosis, all diseases of the lower animals and all affections of man, are very closely related if not identical. They were grouped together. Now we know that the bacteria of glanders and tuberculosis and the fungus of actinomycosis, are as different as three species of the flowering plants. Recently, five diseases of swine known to the veterinarians of Europe, were positively demonstrated by Jensen to be caused by the bacillus of rouget, and thus varieties of one and the same disease. With the existence of definite etiological factors, the isolating and grouping of diseases must continue until they are classified in accordance with this standard. Some one asks what difference does it make? The answer must be first, that right is right; and secondly, when all of these diseases are treated directly or indirectly with some product of their specific organisms as in the case of diphtheria antitoxin of today, we cannot hope for good results save in cases of disease, no matter about its form, which are due to the same etiological factor.

This lead us to the cause for the variation in the course of infectious diseases. The difficulty of becoming enlightened on this highly important topic, without resource to experimental pathology is obvious. By its aid much has been learned concerning the fundamental principles involved, although this field has just been opened. The causes may be cast in a simple equation, namely, the course of the disease will change in ac-

Digitized by Google

cordance with variation in either the resistance of the animal or the virulence of the specific bacteria. Thus, for example, the bacterium of an acute septicaemia which should ordinarily cause death in a rabbit in eighteen hours, may be changed so that the lesions may become peritonitis, pleuritis, pericarditis, subcutaneous or deeper seated abscesses. In swine we often see abscesses in joints due to the localization of bacteria which ordinarily cause an acute general disease, but which owing either to their attenuation or to the resistance of the host, have produced painful and long suffering localized affections. In human pathology, such localized lesions are common and the desirability of extending similar investigations with the etiological factor of all of the infectious diseases is apparent. The formula is simple; but define for us who can, the range of influences which may modify that subtle property of bacteria we call virulence. What elements in the body impart to it a natural resistance? Really, what are these vital forces about which men talk so freely and know so little?

If we pass below these more superficial but perplexing questions, we are met with those concerning the influence of the host upon the parasite. One of them has already found expression in the assertion that "the continued passage of a species of bacteria through a single species of animals, tends to increase its virulence for that species and to attenuate it for all others". This hypothesis, which needs to be verified, is one of vital importance respecting the transmission of infectious diseases, such for example as tuberculosis from animals to man and *vice versa*. If we could continue to call up questions in this department, which are still unanswered, we would soon learn that notwithstanding the much already known, all of the articles in the final constitution of preventive or sanitary medicine have not been written. Schools and theories of medicine which were largely based on individual opinions are rapidly disappearing and the science of medicine, which governs its practice, is being constructed in accordance with the results of the biologic study of disease.

Digitized by Google

The unanswered questions are not all concerning etiology. Before the ideals of the most far seeing advocates of preventive medicine are realized, millions of individuals will have become infected and their restoration to health is the final demand upon the physician. The trend of therapeutics in the line of serum therapy is well known. The marvelous success with diphtheria antitoxin gives hope that somewhat similar methods will bring about like results with other maladies. The problems here are numerous and nowhere in the realm of human research is there a field involving such a variety of factors. Physiology, chemistry, physics, all have their share to do in this field of applied biology. "Surely there is as much pure gold of science to be gathered in working out these problems applicable to the every day life of the individual and to the State as in other kinds of inquiry aimed at a supposed higher mark".

I have tried in this short address to bring to your attention certain very general considerations concerning the inseparable relations existing between disease and the acting forces of nature. It has been possible to touch upon only a few of the many topics which suggested themselves, and these inadequately. We have seen, however, that many diseases depend for their existence upon well defined biologic agencies, while others seem to take origin in the influence of a greater variety of forces. It is to the interpretation of these as yet obscure factors in the production and in the healing of disease that future research will, in part at least, be directed. Although many of these investigations seem to be independent of the microscope and microscopic methods, others and equally important ones rely entirely for their success upon them. More than this, the every-day application of the existing knowledge of the nature and cause of disease require the constant use of the microscope and the fullest interpretation of the facts call for still better methods. As we return to our accustomed places let us take up with renewed zeal the struggle with the problems in hand, not wavering for the reason that Browning gives:

"Knowing ourselves, our world,
Our task so great,
Our time so brief".

Digitized by Google

DAVID SIMONS KELLICOTT

Digitized by Google

Digitized by Google

DAVID SIMONS KELLICOTT.

Professor David Simons Kellicott, B. Sc., B. Ph., Ph. D., was born at Hastings Center, N. Y., January 28th, 1842; died at Columbus, Ohio, April 13th, 1898. He was married to Valeria Stowell, who with one daughter, Gertrude Stowell, and one son, William Erskin, survive him.

After a preliminary education in the elementary schools and the academy of his native place, he in 1865 entered Genesee College, now Syracuse University. Forced to interrupt his college work for a time, he came to Ohio, where he taught school at Scioto Furnace. Resuming his college work he was graduated in 1869 with the B. Sc. degree and in 1874 he obtained from his alma mater the B. Ph. degree. In 1881 he took from the same institution the Ph. D. degree. Immediately upon his graduation he was called as teacher of Mathematics and Botany to Mexico Academy. After one year's work there he became instructor in Mathematics and Natural Science in the Keystone State Normal School, Berks county, Penn. In 1871 he was made teacher of natural science in the State Normal School at Buffalo, remaining until 1888. During this time he also served as Dean and Professor of Botany and Microscopy in the Buffalo College of Pharmacy. In 1888 he was appointed to the chair of Zoology and Comparative Anatomy at Ohio State University, which chair then included all of animal (and human) biology. In 1891 the department was divided, Professor Kellicott taking the new chair of Zoology and Entomology, which he held at the time of his death—a close the more tragic since he was about to occupy, and in fact had already made preparation for moving into, the new laboratory building planned largely after his own wishes and in which his labors would have been, if not lessened, materially lightened.

Digitized by Google

As a teacher he was thorough and conscientious. Hard work was ever his. Nothing that could raise the efficiency of his teachings was ever overlooked or slighted. In all of his work, in or away from the class room, he had in mind its bearing on the teaching of his classes, and his private library and his private collections were freely drawn upon to enhance the value of his instruction. Neither was the practical application of knowledge pushed aside for pure theoretical learning and the mind-training resulting therefrom. He established a course in Entomology having for object the teaching of such facts as could be applied in the farming of plants and animals. To his effort is due the course preparatory to the study of medicine at the Ohio State University, which is specifically held out to fit such students as intend later to take up the study of medicine, and which provides instruction in the fundamental sciences usually but briefly given in our medical schools.

His conscientiousness was pushed to all but a fault. His time, valuable to himself, was always at the command of any student for even smallest matters. His reward was the respect and love of those working under him.

As a scientist, we find in Professor Kellicott again those characteristics (and how could it be otherwise) which mark the man in all his relations in life: modest, hard-working, accurate, honest. His modesty was that modesty which is not born of weakness or distrust of self, but which comes from a true realization of real worth and power strong enough and great enough not to need continuous assertion and self-aggrandizement. Again, his capacity and will for work, intense and almost incessant, stands out. After a year's close application to his duties, his summers would be spent in collecting tours in this and other states or in investigations and study at Wood's Hole laboratories or later at the Lake Laboratory established by the Ohio State University at Sandusky in 1895. Some respite would come in this time by his attendance at the meetings of the various scientific bodies of which he was a member, but even here his activity would manifest itself, for he was not a mere spectator or listener—he was himself a contributor, and

Digitized by Google

busy in administrative and executive affairs of these societies.

He was a keen and accurate observer, quick to sift the essential from the unessential. His writings and presentations were always impersonal and thoroughly honest. What a compliment that is! In his earlier investigations he busied himself with the study of those low but beautiful forms of animal life, the infusorians and the rotifers. In this field he was an authority. Conversant as he was with this small-large world, he added to the knowledge of their life history several new species. Later the study of Lepidoptera absorbed his attention and the allied forms of Odonota captivated his attention. Here again science was enriched with facts of his assiduous gathering and new species were added to the lists. With all this, he found time for the study of plant and animal parasites, and he directed his thoughts largely to the economic side of this problem.

To this industry must be added the fact that he kept well informed, and needs must be for his teaching duties, in the general field of Biology. His zeal is further attested to by his membership in scientific societies. He was a member of the University Ornithological Society, of the Biological Club and a free contributor to their proceedings. His interest here was a valuable incentive to the student members. The Columbus Horticultural Society was also fortunate in having him an active member, with pronounced influence on their work. Other larger societies had the benefit of his association in work and in counsel. He was enrolled in the Ohio State Academy of Science, Fellow of the Royal Microscopical Society, in the American Microscopical Society and in the American Association for the Advancement of Science. The esteem in which he was held in these bodies and the valuation placed on his attainments is apparent from the positions he held in them. His services were utilized in important committees. He was often elected secretary or treasurer, and he held many higher positions of honor. In 1888 he was president in this Society, and at the 1897 meeting he was again elected to this office for the present year. In 1895 he was President of the Ohio State Academy of Science. At the Detroit meeting held last summer he was

Digitized by Google

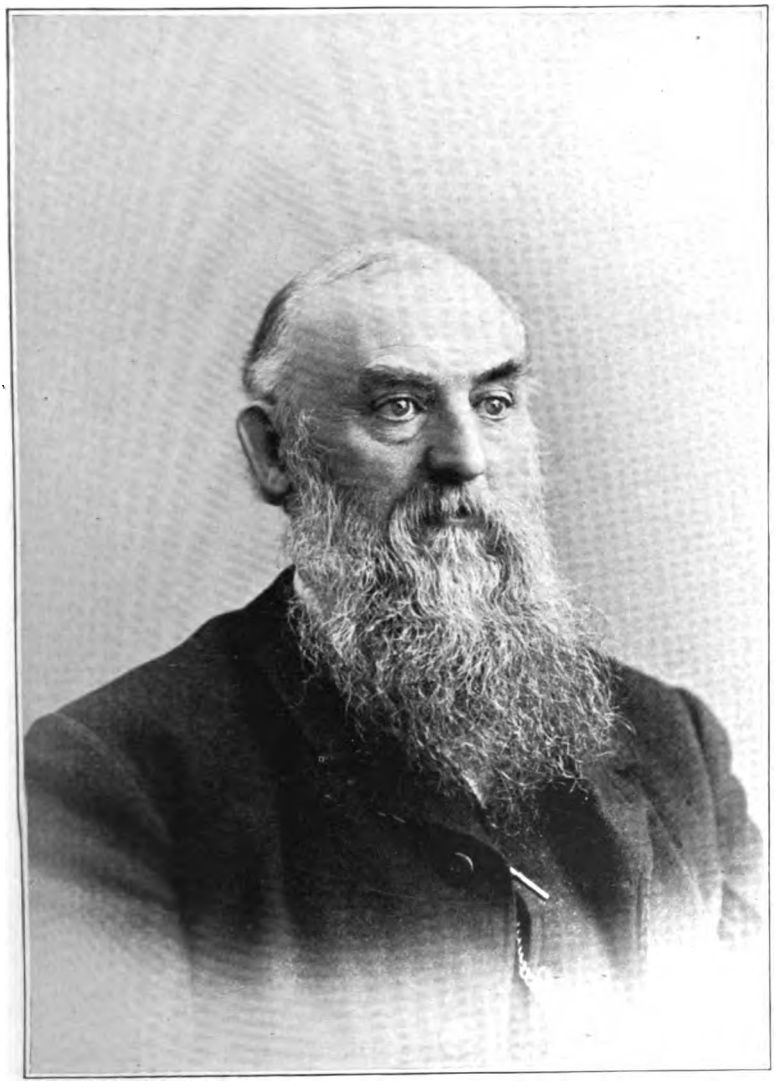
made general secretary of the American Association for the Advancement of Science. A prominent feature at the meetings of these various organizations will be the willing tribute paid to their late member and the sincere expressions of the loss sustained by them.

The writings dealing on the subjects already indicated are found in the transactions of his societies and in various journals devoted to such topics. Some of his publications will remain a lasting monument to his ability, skill and knowledge. A list of his published contributions, perhaps not quite complete, gives us sixty numbers. One of the latest is a laboratory guide just from the press entitled "Dissection of the Ophidian." Its preparation was largely a labor of love for the benefit of his students. The other book, "The Odonota of Ohio", is a complete key and full species-description of these animals. This work is just about to be published, and is the last legacy left us.

His attainment in other and kindred branches of learning bespeak the broad and well educated mind. So stands our scientist, a specialist. Specialist of whom the layman often says, such a man is one-sided with interest and comprehension only in one narrow science; with no interest in the affairs of men and things outside. How false would this be of Professor Kellicott. Others will bear witness to his big heart, with room and love for all things. Well do we of this Society remember that in collecting trips made with him at the scientific gatherings, no one enjoyed more than he the beauties of field and hill and lake and stream. He got from this spectacle more than the artist, for in addition this great scripture was to him not only a book brilliantly bound and gorgeously illuminated—his knowledge of details, his specialism, taught him the types used in its printing, and he could read the words now beautiful, now sublime, formed by their combinations. As a teacher, as a scientist, his loss will long be remembered. To his standing as a man, the many tokens of respect and the heartfelt expressions of sympathy so freely given, bear ample witness.

A. M. Bleile.

Digitized by Google



WILLIAM A. ROGERS

Digitized by Google

Digitized by Google

WILLIAM A. ROGERS.

Professor William A. Rogers, A. M., Ph. D., LL. D., was a man of such strong character and able mind that he naturally became a member of all the great societies which came within the limits of his activity. His main work was in Astronomy and Physics, fields in which accurate measurement is as important as in Microscopy.

To insure accurate measurement he investigated the various standard measures of length available and came to appreciate the high value of the microscope in this investigation. Therefore while he was an Astronomer and Physicist and used the microscope only as an instrument of precision, his sympathies turned to the group of men then known as the American Society of Microscopists, noting that among their efforts, the realization of accurate micrometers was earnestly sought.

In 1882 he joined this Society and at nearly every meeting since that time he presented one or more papers bearing upon micrometers or micrometry and upon expansion and contraction which so vitally concern this accuracy.

While his interest in accurate measurement might have been the primary reason for joining the Society, his broad and generous mind entered into sympathy with the Society's work as a whole. At the time of joining in 1882 he was fifty years old and had a national if not an international reputation, hence he was in a position to render great assistance in the general management of the Society. His general good sense acted as a break on some of the radical members; but as I look back over his career among us, what appeals to me most strongly was his interest in the younger members. His words of encouragement and praise for any creditable work were so genuine that one could not help feeling that one would do his best to make the next work more worthy of the generous recognition.

Digitized by Google

Professor Rogers, in spite of his other duties and engagements, never hesitated to bear more than his share of the burden of the Society. In turn the Society gave to him all the honors it had to offer; and although it had not the reputation of many of the societies of which he was a member, yet in the performance of his duties toward this Society no one could have been more conscientious and painstaking. I presume the preparation of no address by a President of the Microscopical Society ever cost more labor and solicitude than the one given by him at the tenth annual meeting in Pittsburg, in 1887.

It has just been said that Professor Rogers came in to be one of us, to give his unstinted labor and impart some of his wholesome enthusiasm and faith in the value of our work. He did all this and more. In times of depression, he gave not only general encouragement but showed in detail how to advance the interests and increase the success of the Society.

That the honor was to us rather than to him, is shown from the fact that the year before joining the American Society, he had been made an honorary fellow of the Royal Microscopical Society of London.

He was a fellow of the American Association for the Advancement of Science and was three times honored by a chairmanship of its sections. In 1873 he was elected to membership in the American Academy of Arts and Sciences.

Yale College conferred upon him the honorary degree of A. M. in 1890 in recognition of his work in Astronomy. In 1886 Alfred University, at its semi-centennial, gave him a Ph. D.; and finally in 1892, 35 years after graduation, his *alma mater*, Brown University, conferred upon him the degree of LL. D.

Professor Rogers was a teacher and an investigator. His warm heart and noble enthusiasm made it easy for pupils to follow him. His investigations were guided by so clear a mind and prosecuted with such tireless industry that success rarely failed to crown his efforts.

In 1857 he became an instructor in Alfred Academy, and in 1859, Professor in Alfred University. From 1870 to 1886 he was connected with Harvard University, most of the time as

Digitized by Google

Assistant Professor of Astronomy in the Observatory. In 1886 he became Professor of Physics and Astronomy in Colby University; and at this time when the nation is so proud of its navy, it should not be forgotten that he served in it from 1864 to the close of the war.

In 1897 Professor Rogers resigned his chair at Colby and was made the head of the Babcock School of Physics which had just been established in Alfred University; and its plans laid with all the wisdom and experience which his long and fruitful life had given him. His ripest experience was thus to work in the same field that had felt the uplift of his youthful enthusiasm nearly forty years before. But like many another circle of human hope and aspiration, this was not to be completed. On March 1, 1898, death came. SIMON H. GAGE.

NOTE—For other details concerning the life and work of Professor Rogers the reader is referred to the Quarterly Bulletin of Alfred University, July, 1897, and to the Physical Review, Vol. VI, pp. 315-319. Both contain a portrait and a list of his scientific papers.

For the portrait printed herewith the Society is indebted to the courtesy of Alfred University.

Digitized by Google

HENRY C. COONS.

The life of Professor Henry C. Coon, A. M., M. D., Ph. D., was that of a devoted teacher. Every opportunity for improvement was seized by him, and every benefit gained for himself was generously passed on to his pupils in the departments of Physics and Chemistry at Alfred University.

In 1882 Dr. Coon became a member of this Socirty. While he did not furnish papers for its proceedings, he gave his encouragement and support. If it may properly be so expressed, he was one of our faithful "lay members" on whose presence we could count, if the meetings were within reach, and in whose financial support we were never disappointed.

Surely such earnest, true men are a blessing upon the earth, and have an honored seat in our household. It is with regret that we part with them forever.

Dr. Coon was born at West Edmeston, N. Y., in 1828. He died at Alfred University in May, 1898.

SIMON H. GAGE.

Digitized by Google

SPECIAL STRUCTURAL FEATURES IN THE AIR-SACS OF BIRDS.

MARY J. ROSS.

The general structure of the respiratory apparatus of birds has, from early times, attracted more or less attention. Nearly every phase of the subject, with the exception, perhaps, of the histologic, has been minutely and carefully investigated. Various birds, as the ostrich, eagle, hawk, sparrow, pigeon, canary and chicken have been studied.

It is the purpose of this paper to discuss the histologic structure of the accessory organs of respiration—the air sacs, as found in the chicken. But before doing so it will be advantageous to review briefly certain peculiarities of the respiratory organs that are intimately correlated with these sacs. The work was conducted in the Anatomical Laboratory of Cornell University, under Dr. Hopkins, to whom I am greatly indebted for kindly interest, valuable suggestions and personal assistance.

Some authors have denied to birds the existence of a diaphragm; but, now, though in structure very different from that of the mammal, two are generally conceded, since the discovery of their use. When the body cavity is opened from the ventral side, the viscera of the thorax and abdomen are seen to occupy the median plane. A tightly stretched sheet of fibrous tissue (oblique septum) on either side serves to hold them in place. These fibrous sheets practically divide the body cavity into thorax and abdoman, as does the diaphragm in mammals. Closely adhering to the ventral surface of each lung, and forming with the oblique septum a closed cavity, is another so-called diaphragm (the pulmonary). These diaphragms resemble closely the air-sacs, but examined minutely are found to be of heavier texture and are less transparent. To the diaphragms are

Digitized by Google

attached certain respiratory muscles, which move them in such a manner as to cause the lungs and air-sacs to alternately contract and expand.

"The respiratory apparatus presents modifications more remarkable than those of the circulatory", says Milne-Edwards. Connected with the lungs are large membranous sacs, spread throughout the whole body, and extending even to the cavities of the bones. There are nine of these sacs, of which the thorax contains seven—one thoracic, two cervical, two anterior intermediate, two posterior intermediate, while the abdominal cavity contains but the two abdominal sacs, partially held in place by the diaphragms (Fig. 1). These sacs communicate with the lungs by five perforations on the ventral surface of each lung (Fig. 1). It is stated that some sacs have more than one opening into the lung; but in the chickens which I have examined (ten or more) there was but one orifice to each sac, excepting the thoracic, which contains two, one into each lung, thus making five openings on either side (Fig. 1).

All authors, with the exception of Sappey, who in any way mention the inter-communication of the air-reservoirs, do so but to affirm it. Even Wiedersheim states that all, with the exception of the posterior intermediate, may and often do communicate with one another. Yet, notwithstanding these repeated affirmations, there has been no detailed description as to the manner in which they communicate, or at what point this communication occurs. After careful examination the sacs were found to be entirely independent of each other, thus tending to confirm Sappey's statements as to their non-intercommunication.

The lungs of birds contrast strikingly with those of mammals. They are closely attached to the ribs and vertebræ, are very small, semi-elliptical in shape, of a light rosy hue, and in general texture much more fragile than the lungs of mammals. Then, too, they are not divided into distinct lobes as in certain mammals; their lobulated appearance being due simply to the deep indentations of the ribs and transverse processes of the vertebræ. However, the distinguishing characteristic of birds

Digitized by Google

lungs lies in the distribution and termination of the air passages within the lung tissue. In mammals the bronchial tubes pass directly centrad, before sending divisions to the periphery of the lung: in birds they are disposed at the periphery then transmit branches centrad. Sappey's work seems to show conclusively that the bronchioles, instead of ending in a series of alveoli as in mammals, anastomose with one another. Thus a continuous aerial network is formed. Yet Parker makes the following statement: "Besides the branches to the air-sacs, the main bronchus gives off secondary bronchi, and these branch again, sending off tubes, which end blindly near the surface of the lung and give off blind dilations commonly known as alveoli". In my work on the chicken it was found that if the mesobronchium (Fig. 1, M) be opened and an injection made through the first entobronchium (G) the injection mass penetrates rapidly into the cervical sac (Ar). But almost simultaneously it returns to the mesobronchium through the second and third entobronchia. The liquid reentering the mesobronchium does not nearly equal in amount that which passes to the cervical sac. But if the pressure is continuous the liquid circles around in a constant stream. Some of the liquid also penetrates to the other air chambers. Unless there is anastomosis of the bronchioles it does not appear possible for this to take place. Another experiment that was tried to demonstrate the bronchial anastomosis, requiring much greater care than the one just mentioned, is as follows: The lung of a freshly killed chicken was exposed by removing the surrounding viscera, as the heart, lungs, etc. The pulmonary blood-vessels were tied and all orifices into the air-sacs closed. This latter may be done either by tying or, more easily, by plugging them with cotton. Colored collodion mass was then injected through the main bronchial tube. As soon as this mass becomes somewhat hardened the lung was carefully removed and placed in artificial gastric juice until all of the lung tissue is digested out. The course of the bronchioles can then be traced more readily than in the fresh tissue. However, this method is not entirely satisfactory as the very small

Digitized by Google

branches are easily torn, and the connection is thus apt to be lost. Yet enough may be traced to prove that branches from one main bronchial tube anastomose with those from another. In such a preparation as this, the courses of the main branches are clearly shown; how that on leaving the mesobronchium they pass to the dorsal and ventral surfaces, completely covering them with their ramifications. They then pass to the centre, dividing into minute bronchioles, connected with each other. With the exception of the anastomosing bronchioles, the histologic structure of the lungs resembles that of mammals. The air-sacs are thin, transparent membranes, with a more or less fibrous connective tissue basement. Guillot aptly compares them to soap-bubbles. And, when inflated they do resemble large soap-bubbles—slightly glistening, easily destroyed.

All the sacs, with the exception of the thoracic (Fig. 1, T) can be freed from their connections with the adjacent tissue. But there is a close adherence of the thoracic sac to the walls of the thorax. This sac may be distinguished from the rest in having membranous folds partitioning its cavity. Every organ traversing it is completely ensheathed by these folds and so held in place. It extends around the articulation of the shoulder, as the axillary sac, and into the cavity of the humerus (Fig. 1, Ax, H). There were two cases in which the humerus was not pneumatic, and in no case where the femurs were examined were they hollow.

Stricker in his Manual of Histology asserts that the epithelial lining of the sacs is pavement, and that cilia are present in the sacs only near their connections with the lungs. As regards the general character of the epithelium this statement is correct. If a section be taken of any portion of the sacs not attached to the walls of the body the epithelium is pavement. But in a section taken from near the connection of the sacs with the lungs, the epithelium as it leaves the bronchial tubes becomes columnar, gradually changing to pavement epithelium. If the epithelium is stained with silver nitrate the outlines of the cells are brought out distinctly. For this surface-view of the cells

Digitized by Google

it is better to examine a two or three days old chick. Here there is no need of a stain. The cells are pentangular, with round nuclei (Fig. 5). If examined while fresh they appear granular and exhibit cilia in motion. Where the membranous sacs are attached to the surrounding tissue a change in the character of the epithelium is apparent. Take for example a section of the small muscle which passes through the thoracic sac, from either side of the trachea to the body wall. Upon examination we find the epithelium to vary greatly. Flattened, *i. e.* pavement, cuboidal and columnar cells are all present in the same section (Figs. 2, 3, 4). This variation might possibly be ascribed to muscular contraction; however, at the juncture of the muscle and body wall adipose tissue was present in all the specimens examined. Here again where no muscular contraction was possible the same cell changes were noted. Sections of blood-vessels, both veins and arteries, and of muscle from the wall of the thorax also exhibit the same variations in cell outline. There was also noticed a slight difference in the length of the cilia, that on the columnar cells being the longest (Fig. 2).

Stricker's statement as to the presence of cilia is only partially correct. Cilia are present near the connections of the sacs with the lungs, as he says. *But they are also present over the entire surface of the sacs contained within the body cavity.* Fresh tissue taken from the dorsal as well as from the ventral surface, from the farthest extremity of the abdominal sacs, as well as from near the connection with the lung, exhibits rapidly moving cilia. Various parts of all nine sacs were examined with the same result; cilia were found everywhere. Although the epithelium of each of the nine thoracic and abdominal sacs is ciliated, as just mentioned, repeated examinations failed to disclose any cilia in the evaginations, or prolongations of the thoracic sac around the head of the humerus, (Fig. 1, Ax) and of the abdominal sac around the head of the femur; nor were any found in the cavities of the bones. As the axillary sac (Fig. 1, Ax) is usually of considerable size and in part attached to the muscles of the arm, histologic study of both fresh and

Digitized by Google

sectioned tissue is easy. But though several specimens were carefully examined no trace of cilia could be found. The sections were as in Fig. 5 but without cilia. Then the bones were examined, but here again there was no trace of cilia. If the removal of exfoliated epithelium and foreign substances is the principal use of the cilia it is difficult to understand why they are only present in part of the membranous sacs; for the openings from the axillary prolongations, at least, are as large as those from the lung to the thoracic sac (Fig 1, C).

To summarize briefly: The epithelial lining of the membranous sacs is pavement, except where the sac is attached to the surrounding tissue. Here there are variations in the form of the cells, ranging from pavement to columnar epithelial cells. Cilia are present over the entire surface of the sacs contained within the body cavity, but absent from the prolongations of the sacs in the joints and in the cavities of the bones.

Digitized by Google

EXPLANATION OF FIGURES.

All figures are drawn by the aid of a microscope and an Abbé camera lucida, except Fig. 1, which is purely diagrammatic. Figs. 2, 3 and 4 are taken from transections of the muscle connecting the trachea with the body wall, and passing through the thoracic air-sac. The muscle is not drawn in Figs. 2 and 3.

Digitized by Google

PLATE I.

Fig. 1. Diagram to illustrate the relative size, relation, and connection of the lungs and air-sacs.

ABBREVIATIONS.

A. Orifice from lungs to abdominal sac.

Abd. Abdominal sac.

Ant. I. Anterior intermediate sac.

Ax. Axillary prolongation of thoracic sac.

B. Orifice from lungs to posterior intermediate sac.

C. Orifice from lungs to thoracic sac.

Cer. Cervical sac.

D. Orifice from lungs to cervical sac.

E. Orifice from lungs to anterior intermediate sac.

F. Ectobronchia.

Fur. Furcula.

G. Entobronchia.

H. Prolongation of axillary sac to the cavity of the humerus.

L. Lungs.

M. Mesobronchium.

Post. I. Posterior intermediate sac.

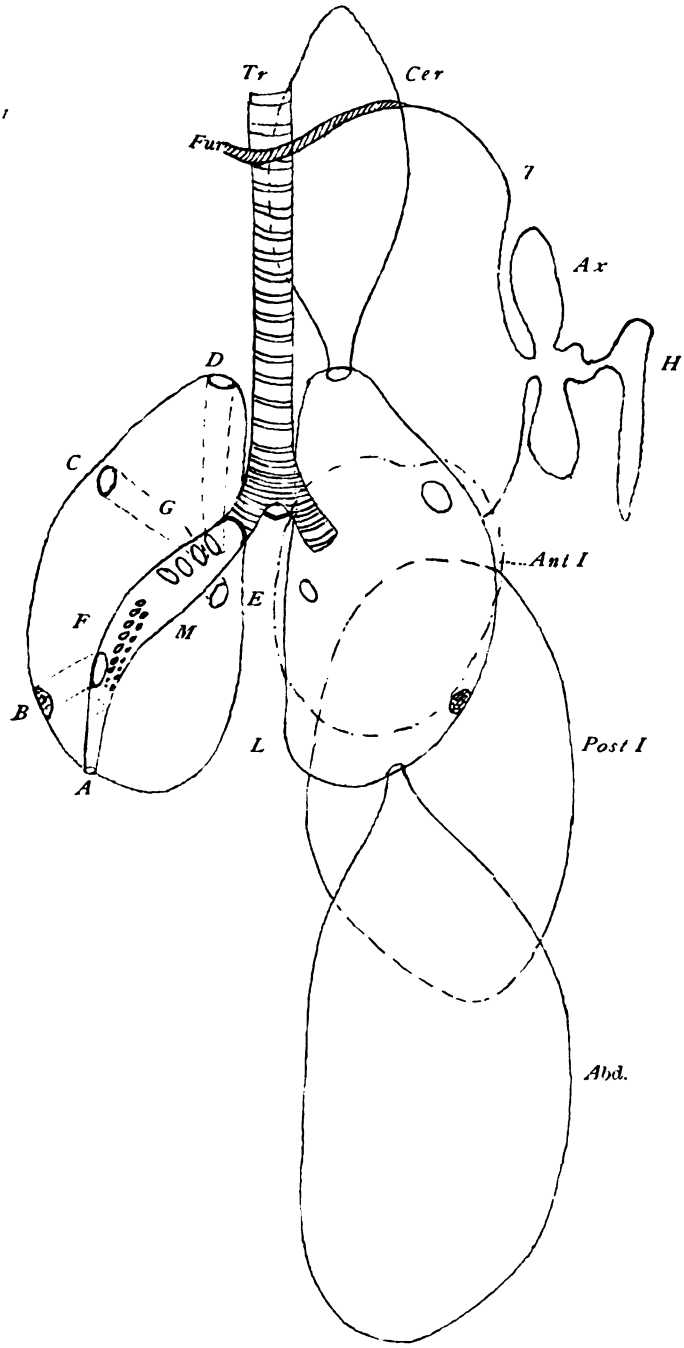
T. Thoracic sac.

Tr. Trachea.

Digitized by Google

PLATE I

Fig. 1



Digitized by Google

Digitized by Google

Digitized by Google

PLATE II.

Fig. 2. Transection of muscle surrounded by the thoracic sac, showingciliated columnar epithelium,(*Col.*) with basement membrane of fibrous connective tissue (*Bm.*)

Fig. 3. Ciliated cuboidal epithelium, (*Cub.*) with basement membrane (*Bm.*)

Digitized by Google

PLATE II

Fig. 2

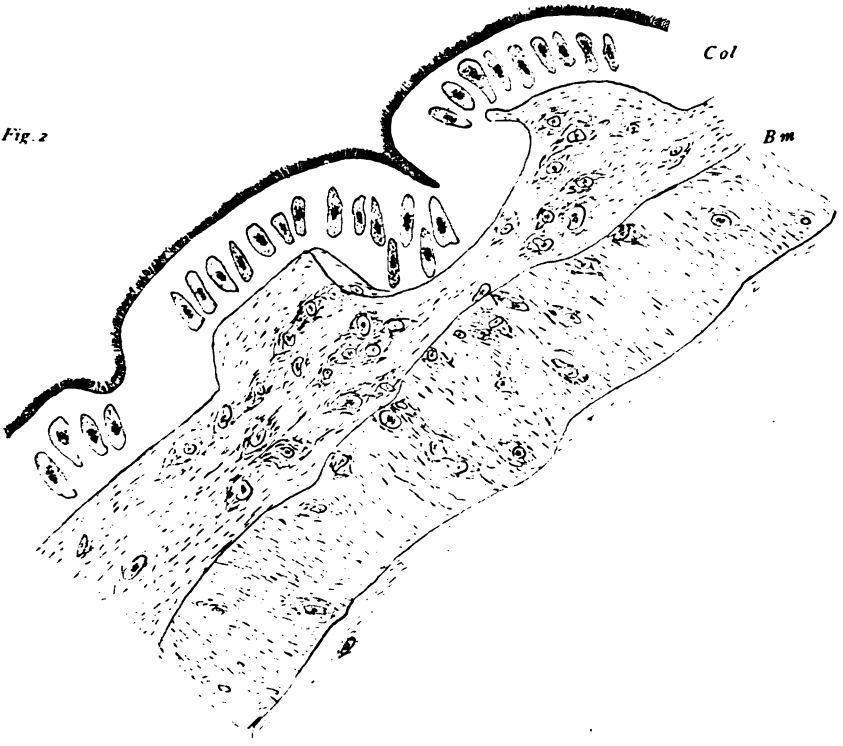
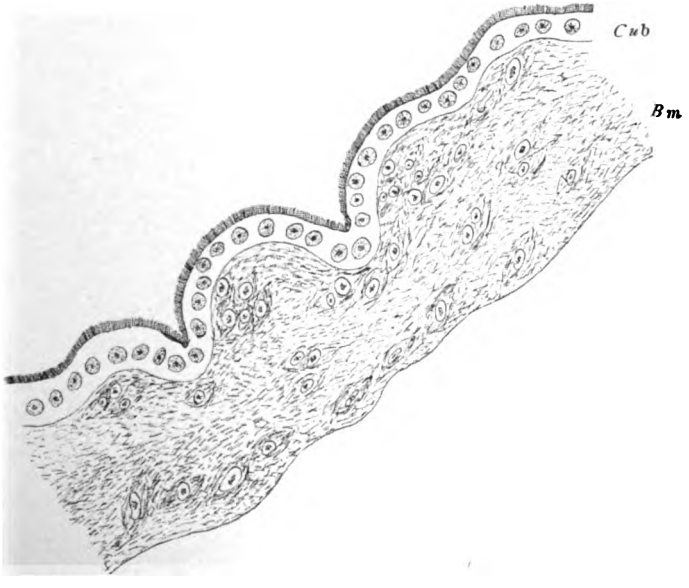


Fig. 3



Digitized by Google

Digitized by Google

Digitized by Google

PLATE III.

Fig. 4. Transection of muscle.

M. Transection of striated muscle.

Bm. Basement membrane.

P. Pavement epithelium.

Fig. 5. Surface view of pavement epithelium of the air-sacs, showing cilia and round nuclei in pentangular granular cells.

Digitized by Google

PLATE III

Fig. 4.

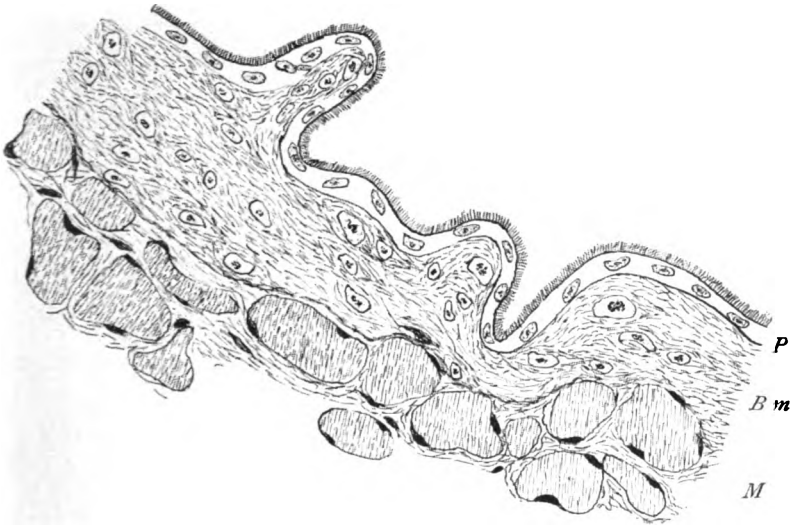
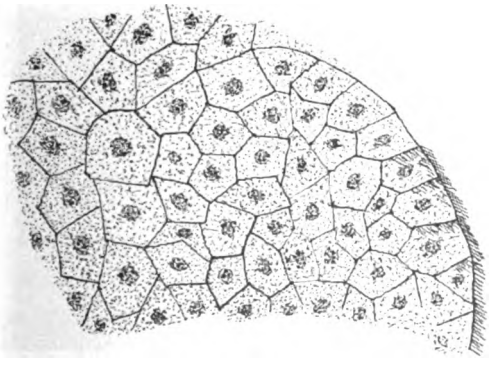


Fig. 5



Digitized by Google

Digitized by Google

MICROMETRY OF HUMAN RED BLOOD CORPUSCLE.

BY FRANK JUDSON PARKER, PH. B., M. D.

The commonly accepted average diameter of the red blood corpuscle of man is 1-3,200 in. or 7.9 microns, and although some observers have given smaller averages and some have reported larger measurements, no marked distinctions have been discovered between the corpuscles of different races or different nationalties.

The possible, (indeed, the probable), cause of differences reported by various writers is attributed by Dr. M. C. White, Proceedings of American Microscopical Society, 1896, Vol. XVIII., pp. 204, 205, to the different amounts of the corpuscle measured. Some rejecting all the dark border, others measuring one-half the dark border, while others include the whole of the dark border on both sides in their measurements.

Prof. Cabot, in his recent book on Human Blood, calls attention to a statement by GRAM that "Measurements published by observers living in Southern Europe are smaller than those of Northern Europe, viz: Italians, 7 to 7.5 microns; Germans, 7.8 microns; Norwegians, 8.5."

To further investigate this question, at the suggestion of Prof. White, I have made the measurements reported below.

The measurements here reported have been made by the author using Bullock's microscope, with a $\frac{1}{8}$ inch objective made by Spencer and an Abbé condenser, Zentmayer's cobweb micrometer eye-piece and a stage micrometer by Leitz, ruled to 1-100 millimeter. This gave for each turn of the screw of the micrometer 6.85 microns, and as the screw head was graduated to 100 divisions, the micrometer is calculated to measure to 0.0685 microns or about 1-350,000 of an inch.

Digitized by Google

Each preparation of blood measured was placed upon a glass slide, dried and covered with thin glass.

Blood was measured from the following subjects, viz:

From F. J. Parker	100	Corpuscles
Girl from Finland, age 25, 3 months in America	500	"
Esquimaux girl, came with Peary	500	"
American girl, age 17	500	"
Italian boy, age 17, in America 3 months	500	"

Digitized by Google

TWO THOUSAND ONE HUNDRED RED BLOOD CORPUSCLES MEASURED BY FRANK JUDSON PARKER, PH. B., M. D., YALE UNIVERSITY.

Source of Blood	Number of Corpuscles Measured	Average Diameters in Microns	Maximum and Minimum by Tens	Maximum and Minimum by Twenties	Maximum and Minimum by Fifties	Maximum and Minimum by Hundreds
American girl, 17 years old.	500	7.90	Max. 8.48 Min. 7.52	Max. 8.40 Min. 7.61	Max. 8.76 Min. 8.14	Max, 8.03 Min. 7.79
Italian boy, 17 years old. In America three months.	500	7.99	Max. 8.48 Min. 7.62	Max. 8.47 Min. 7.62	Max. 8.47 Min. 7.62	Max. 8.12 Min. 7.89
Girl from Finland, age 25 years in America three months.	500	7.89	Max. 8.28 Min. 7.61	Max. 8.24 Min. 7.62	Max. 7.96 Min. 7.76	Max. 7.96 Min. 7.76
Esquimaux girl, about 14 years old, came with Lieut. Peary.	500	8.07	Max. 8.68 Min, 7.65	Max. 8.48 Min. 7.63	Max. 8.26 Min. 8.06	Max. 8.16 Min. 8.04
F. J. P. age 23.	100	7.81	Max. 8.05 Min. 7.68	Max. 7.90 Min. 7.66	Max. 7.86 Min. 7.76	
Five persons as above.	2100	7.95	Max. 8.68 Min. 7.52	Max. 8.47 Min. 7.61	Max. 8.47 Min. 7.62	Max. 8.16 Min. 7.76

Digitized by Google

Here we find that the blood of the Italian boy (7.99 microns) is a trifle larger than that of the American girl (7.90 microns); that of the girl from Finland, (7.89 microns), not as large as that of the Italian, whereas on Gram's theory it ought to be larger, and that of the Esquimaux girl (8.07 microns), though a trifle larger than any of the others, is not as large as Gram reports for the Norwegian, though coming from a higher latitude.

The result of this investigation fails to show any marked distinction that could be attributed to difference of climate or nationality.

NOTE.—When Dr. Parker had just finished the measurements here reported he was called to the service of the United States with the Connecticut Naval Reserves and I have copied his table of measurements and put the paper in shape for presentation to the American Microscopical Society. M. C. WHITE, M. D.

Digitized by Google

THE REGENERATION OF THE INTESTINAL EPITHELIUM IN THE TOAD (*BUFO LENTIGINOSUS AMERICANUS*) DURING TRANSFORMATION.*

B. F. KINGSBURY.

The phenomena of metamorphosis are perhaps best exemplified in the transformation of the tadpole into the frog or toad, or the caterpillar into the butterfly, and certainly are in these forms best known to the non-professional observer. To the biologist they present a field of investigation both suggestive and puzzling in its results. The remarkable changes of form and structure which occur necessitate a more or less complete distruction of parts with a subsequent regeneration to form the tissues of the adult body,—changes often comprised within a remarkably short period of time when it is considered how extensive they are.

In the higher orders of insects these processes of histolysis and regeneration are most extensive. In the frog and toad the changes easily recognized are the growth of arms and legs and the disappearance of the tail, whereby the animal is suited for a terrestrial instead of an aquatic existence. The alimentary tract likewise undergoes marked changes in preparation for the substitution of an animal for a vegetable diet. The mouth is widened, the horny beak is lost and true teeth developed; there occurs a differentiation of a stomach and rectum, accompanied by a marked shortening of the intestine as a whole. It is with the histolytic and regenerative changes in the intestinal epithe-

*The following note is a fragment of a more extensive investigation upon the minute structural changes that occur in the toad during the period of transformation into the adult, and was undertaken in connection with work by Professor Gage of Cornell upon the habits and life-history of the animal. The colored figures by which this article was illustrated when read will be published with the final paper.

Digitized by Google

lium that the present paper deals. In the yet untransformed tadpole, in which the legs are quite well developed but before the arms have yet broken through, the intestinal epithelium presents the appearance characteristic of the Amphibia: it possesses a simple columnar epithelium, thrown into folds when the intestine is contracted. Connected with the epithelium and hanging down from it or partially intercalated between the bases of the columnar cells are clusters of three or four small cells with scanty protoplasm, which have been generally homologized with the crypts of Lieberkühn of mammals. A lumen is but rarely to be recognized in these clusters in Amphibia, though an arrangement of the cells as if surrounding a lumen may be quite often found. In the tadpole, however, such is not the case, and in younger tadpoles cell-clusters as such apparently do not exist. Their origin and first appearance have not been ascertained as yet.

At a later stage, after the arms have been put forth and before there is any appreciable diminution in the size of the tail, these cell-clusters have increased markedly in size, and karyokinetic figures are abundant in them. From these cell-clusters the new epithelium of the transformed toad will be formed and the changes that lead to the final establishment of the adult intestine now follow rapidly, so that, before the tail is more than half absorbed, the new epithelium is completely formed and the old, larval epithelium occupies the lumen of the intestine as a disorganized mass of matter, cell fragrants, nuclei and globules; many of them apparently containing substance of a fatty nature which is stained black by means of osmic acid solutions.

The degeneration of the old epithelium is first indicated by the browner stain given to the protoplasm by osmic acid mixtures such as Hermann's and Flemming's fluids; globules and granules of a brown and black color-reaction with osmic acid appear in the cell body, which becomes vacuolar. The epithelium then begins to disintegrate and cell-outlines become indistinguishable. The nuclei remain for a long time apparently unchanged and may be easily distinguished after the cell bodies are completely destroyed. Accompanying these degen-

Digitized by Google

erative changes in the surface epithelium has been the steady growth of the cell-clusters or crypts. At first they are simply solid balls of cells; soon, however, a lumen appears in the middle of the ball and it becomes converted thereby into a hollow sphere or often a flask whose wall is a single layer of columnar cells. The spheres grow, the side toward the old epithelium opens, the neighboring crypts (spheres) meet one another and fuse, and in that manner a new continuous epithelium is formed. The old disintegrating epithelium is apparently simply displaced, —*pushed* into the lumen of the intestine where it remains as a mass of debris.

The bearing these facts have on the difficult question of the mode of regeneration of the intestinal epithelium is quite interesting and suggestive. At the present day histologists are confronted by two theories as to the mode of regeneration of the intestinal epithelium,—the first, which may be styled the theory of *Erbstein*, which is the older view, is that the new epithelial cells may be formed from the small cells which have been found here and there lying between the bases of the columnar cells, and which are generally spoken of as substitution cells,—a prejudgement of their nature and function. On the other hand, Bizzozero affirms that the crypts of Lieberkühn are the seat of regenerative activity and from their depths proceed new cells to accommodate an expanse of surface or replace cells which have been lost by abrasion. There are several investigators whose results show at least that karyokinesis is much more abundant in the crypts of Lieberkühn of mammals than in the surface epithelium or on the villi,—circumstantial evidence in favor of Bizzozero's theory. The migration of cells from the crypts to the summit of the villi which this theory presupposes, is, it seems to me, rather hard to accept without strong evidence.

Granting the correctness of the homology of what I have spoken of as cell-clusters in Amphibia with the crypts of Lieberkühn in mammals, Bizzozero's theory would find in the regeneration of the epithelium in the toad during transformation an argument in favor of its correctness, since here the new

Digitized by Google

epithelium is entirely formed from the so-called glands or crypts of Lieberkühn.

It is likewise interesting to note that we encounter here in Amphibia quite the same mode of regeneration of the epithelium that has previously been found by other investigators to occur in insects during metamorphosis, and in dragon-fly nymphs at least, to supply loss of cells during normal digestive activity, as the results of some recent investigations (Needham) have shown.

Cornell University.

Digitized by Google

METHOD FOR PREPARING NUCLEATED BLOOD IN BULK FOR CLASS DEMONSTRATION.

T. E. OERTEL.

No book on microscopical technique which I have been able to consult gives a method for preparing blood in bulk.

For class demonstration it is obvious that by having on hand ready prepared material the work will be greatly facilitated and a uniformity of result assured which could not be expected from the faulty manipulations of untrained students to whom blood is usually given for study early in their histological course.

It is much more convenient for the teacher to dispense his preparation from a small vial than to be compelled to make "smears" for a large class. "Smears" are also often unsatisfactory by reason of agglutination or crenation of the corpuscles, excess of serum and the formation of fibrin and much care is required in their proper fixation, by the usual method of heat, in order that the result be not disastrous.

These considerations led me to try and work out a method which would allow of the staining and keeping of nucleated blood in bulk ready for distribution to the class and so fixed that there should be but little distortion of the corpuscles.

The red blood cell is a delicate structure and some care in its manipulation is required.

If the steps of the method are strictly followed one may be confident of a successful issue.

Chloroform the animal selected; a large frog is probably the most convenient; open the thorax, puncture the aorta and allow the blood to flow directly into a small glass jar, with ground glass stopper, containing a one per cent (1%) aqueous solution of osmic acid. The solution should be largely in excess of the

Digitized by Google

amount of blood, at least fifty times as great. The vessel is now closed and set aside for several hours in which time the blood cells will have become thoroughly fixed and hardened and have settled in a thin layer at the bottom.

Decant the supernatant fluid and add distilled water, gently agitating the vessel until the blood is thoroughly mixed with the water. Again decant after sedimentation has taken place or filter rapidly through very thin filter paper and wash off the filtrate in a small quantity of distilled water.

Next add Böhmer's haematoxylin diluted one-half with distilled water. Use no more of this mixture than enough to promote quick and thorough admixture with the water containing the blood. After a few moments staining filter as before, wash the filtrate from the paper by agitating in a large dish of distilled water and set the vessel aside for an hour or more in order that the nuclei of the cells may be well differentiated.

Dehydration is now accomplished by running the blood through various strengths of alcohol beginning with seventy per cent (70%) and ending with absolute, filtration or decantation being practiced with each step. Care must be taken not to use too small a quantity of alcohol or the cells will not be well dehydrated.

Clear in carbol-xylol (carbolic acid one part, xylol three parts), allow the blood to settle in a large test tube or conical glass, draw off as much of the fluid as possible with a bulb pippete and add thin xylol balsam.

Keep in a well stoppered bottle and when wanted for use shake until the blood is thoroughly mixed with the balsam, with a small glass rod transfer a drop to a clean slide and superimpose a cover glass. A neat and permanent preparation is the result.

Digitized by Google

NOTICES OF SOME UNDESCRIBED INFUSORIA, FROM THE INFUSORIAL FAUNA OF LOUISIANA.

J. C. SMITH, NEW ORLEANS, LA.

(Being a continuation from page 68 of the Proceedings for 1897.)

FAMILY TETRAMITIDÆ Kent.

GENUS TETRAMITUS Perty.

Tetramitus oralis. Sp. n. Plate IV., Fig. 1.

Body sub-obovate normally, soft and very changeable in shape; usually more than one and a half times longer than wide; the anterior extremity obliquely truncate and excavate for a variable distance on the ventral surface; posterior extremity very changeable; four flagella, as long or longer than the body, originating together on the anterior border at the summit of the truncation, and usually directed downward; oral aperture simple and located at the inferior extremity of the truncation; contractile vesicle distinct and situated in the posterior body-third near the ventral surface; nucleus roundish and in the anterior body-third; endoplasm granular.

Length from 1-1000 to 1-600 inch; habitat, an old infusion.

This form was found on several occasions very numerous in an old infusion, in company with an abundance of bacteria, on which it was feeding very ravenously. Its shape changes constantly while thus feeding, and often the excavate truncation would become the anterior border. With a ¼ objective the oral aperture could be easily located by the continual entrance of the bacteria and the formation of food vacuoles at that point; these vacuoles were often quite numerous and would circulate through the endoplasm for sometime before disappearing.

Digitized by Google

The family Tetramitidæ includes only the pantostomatous forms, and will therefore exclude this species, but the great resemblance it bears to the *Tetramitus decissus* Perty is the writer's excuse for placing it with this family provisionally.

Family Enchelyidæ Kent.

Genus Enchelys Ehrenberg.

Enchelys vermicularis. Sp. n. Plate IV., Fig. 2.

Body sub-clavate, cylindrical, soft but persistent in shape; about three times longer than wide; annulated distinctly so as to appear as if segmented; between the annulations, the body is encircled with a single row of fairly stout hispid setae; body entirely covered with quite long and active cilia; simple oral aperture apical; contractile vesicle near the posterior border; nucleus roundish and sub-central; endoplasm hyaline and granular; movement rotary and worm-like.

Length, 1-550 inch; habitat, the brackish waters of Lake Pontchartrain.

Genus Tillina Gruber.

Tillina distincta. Sp. n. Plate IV., Fig. 3.

Body sub-reniform, compressed, plastic but persistent in shape; less than twice as long as wide, clothed with short cilia; longitudinally striate; trichocysts abundant; oral aperture situated in the anterior body-half some distance from the anterior border, in a cleft-like depression on the ventral surface; this aperture continued dorsal-ward for some distance as a ciliated and capacious pharynx; the oral cilia a little larger than the body cilia; contractile vesicle in posterior fourth; nucleus round to ovate and sub-central; anal aperture on the ventral surface near the posterior border; endoplasm granular and usually containing an abundance of food.

Length, 1-200 inch; habitat, ditch water.

The activity of the oral cilia is apt to lead one to believe that there is a small membrane there, but the contrary can be easily demonstrated.

Digitized by Google

Tillina megastoma. Sp. n. Plate IV., Fig. 4.

Body somewhat bean-shaped; much compressed; anterior and posterior borders rounded; plastic but persistent in form; twice as long as wide; clothed with fairly long cilia and longitudinally striate; oral aperture located at the upper extremity of the usually straight ventral surface, just below the anterior border, and is continued dorsal-ward, as a very capacious and strongly ciliated pharynx, which curves slightly downwards as it nears the dorsal border; contractile vesicle large and in posterior body-fourth; nucleus very granular, roundish and sub-central; endoplasm granular.

Length, 1-160 inch; habitat, brackish waters of Lake Borgne.

This *Tillina* was taken with every collection from a certain spot in Lake Borgne and was usually found in company with *Litosolenus armatus* of Dr. Stokes.

The writer takes this occasion to mention that the forms of *Litosolenus armatus* found here, range much larger in size than those recorded by Dr. Stokes as found at Long Island. He records 1-150 inch as the maximum size, while the forms found here measured 1-90 inch. The longitudinal striations of the body are not due to the arrangement of the cilia, but to some granular elements of the endoplasm. The very large and densely ciliated pharynx seems to cut the body in twain. It is a very active feeder and usually contains a number of diatoms and desmids.

Tillina granda. Sp. n. Plate IV., Fig. 5.

Body sub-reniform, compressed, elastic and slightly changeable in shape; about twice as long as wide; clothed with fine cilia; faintly striate longitudinally; trichocysts abundant; oral aperture in the nearly central ventral depression, and continued as a crescent-shaped pharynx, which is densely ciliated; contractile vesicle near the posterior border; nucleus ovate, in the anterior body-half and near the dorsal border; anal aperture on the ventral surface near the posterior border; endoplasm brownish and usually containing food balls.

Digitized by Google

Length, 1-90 inch; habitat, ditch water.

This form differs from *Tillina magna* of Gruber, in not possessing the posterior lobate process, which includes the contractile vesicle. It is also very much larger than *T. magna*. At times the concavity disappears and both of its lateral borders are alike. They were taken in large numbers from ditch water; some had the faint longitudinal striations, while others lacked this peculiarity.

Family Lembidæ Kent.

Genus Lembus Cohn.

Lembus ornatus. Sp. n. Plate IV., Fig. 6.

Body elongate-clavate; cylindrical; elastic and from five to six times longer than wide; distinctly annulated; an undulating membrane and a furrow originating near the apex, extend backward on the ventral surface to near the body-center, where it meets the simple oral aperture; this undulating membrane finely striated transversely; body covered with fairly large and active cilia; oral and body cilia not diverse; a single long seta extending from the caudal extremity; contractile vesicle near the posterior border; nucleus elongate and sub-central; endoplasm bluish and granular; reproduction by transverse fission.

Length, 1-350 to 1-210 inch; habitat, brackish waters of Lakes Pontchartrain and Borgne.

The very noticeable difference existing between this form and those hitherto recorded is in the finely striated undulating membrane; these striations are good tests for a $\frac{1}{4}$ objective. The membranes of the largest forms were usually ragged on their free borders. They are abundant and were sometimes found in company with *Chlamydodon mnemosyne* Ehr.

Family Tintinnodæ Clap. and Lach.

Genus Strombidinopsis Kent.

Strombidinopsis paradoxus. Sp. n. Plate IV., Fig. 7.

Body thimble-shaped, soft and changeable in form; cylindrical; posterior border round and anterior border transversely

Digitized by Google

truncate; less than twice as long as wide; peristome simple and bearing a single circle of heavy setose-like cilia, which are as long as a half-body length; disk slightly convex and appearing to open and close the oral aperture by its elevation and depression; oral aperture on one side of the disk and continued downwards as a non-ciliated pharynx; body clothed with very fine cilia, those only immediately below the peristome very evident; contractile vesicle large, in anterior body-half and near the border opposite the oral aperture; nucleus ovate, in posterior body-half just below the pharynx; anal aperture debouching on the pharynx as in Vorticella; endoplasm very granular and usually containing much food; reproduction by transverse fission.

Length, 1-550 inch; habitat, fresh water.

This form was found, in company with *Hymenostoma hymenophora* Stokes, in several collections of water taken from a fish pond in one of the public buildings of New Orleans. In activity, it surpasses the *Urocentrum turbo*. Diatoms, unicellular algæ and small infusorians are consumed by it in large quantities. As a precedent to its feeding, it attaches itself to the slide, an algal filament or debris, by means of a caudal-like filament of its body, which filament sometimes exceeds the body in length. Transverse fission is ushered in by the appearance, at the body center and on the same side as the contractile vesicle, of a circlet of setose-like cilia.

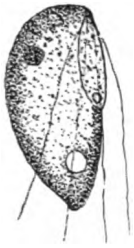
Digitized by Google

PLATE IV.

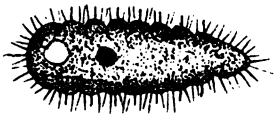
Fig. 1. *Tetramitus oralis* n. sp.
Fig. 2. *Enchelys vermicularis* n. sp.
Fig. 3. *Tillina distincta* n. sp.
Fig. 4. *Tillina megastoma* n. sp.
Fig. 5. *Tillina granda* n. sp.
Fig. 6. *Lembus ornatus* n. sp.
Fig. 7. *Strombidinopsis paradoxus* n. sp.

Digitized by Google

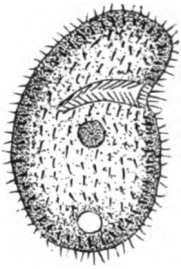
PLATE IV



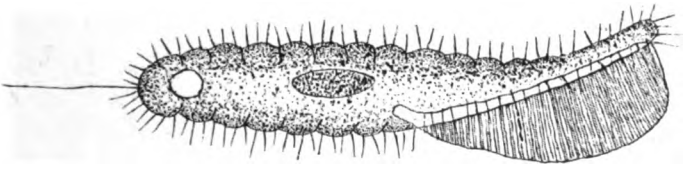
1



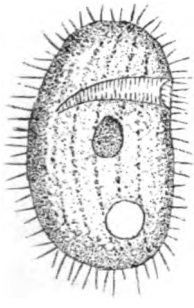
2



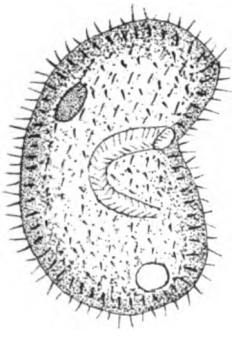
3



6



4



5

7

Digitized by Google

Digitized by Google

THE PERSISTENCE OF BACTERIA IN THE MILK DUCTS OF THE COW'S UDDER.

ARCHIBALD R. WARD, ITHACA, N. Y.

The constant presence of bacteria in freshly drawn milk is a matter of considerable importance. The fact that milk when drawn from the udder may contain bacteria is of the greatest interest in connection with the observance of measures designed to reduce the bacterial content of milk to the minimum. Here, if that fact be true, is one source of the infection of milk which can not be elminated by the exercise of precautions during the milking or the subsequent processes to which it is subjected.

The earlier investigations undertaken to throw light on the question of the presence of bacteria within the healthy udder consisted in counting the bacteria in samples taken during different periods of the milking. Schultz* found a decrease in numbers as the milking progressed. Lehmann† obtained like results. It might be concluded from the work of Schultz and Lehmann that the teats, or at most the lower portion of the cistern, only certain bacteria.

Gernhardt‡ found a larger number in samples from the middle of the milking than at the beginning, although some of the samples from the last milk drawn were sterile. To explain his results, Gernhardt suggests that the bacteria make their way up through the milk ducts of the teats, through the cistern and into the smaller ramifications of the ducts which connect the cistern with the ultimate follicles. Such an assumption explains the wide variation in numbers obtained by him.

*Leopold Schultz. Archiv. f. Hygiene, B. S. XIV. (1892).

†Lehmann. 17te Versammlung d. deut. Ver. f. offent. Gesundheitspflege.

‡Gernhardt. Quant. Spaltpilzunters. d. Milch, Inaug. Dissert. Univ. Jurjew.

Digitized by Google

E. von Freudenreich* states that when in the udder, milk is free from bacteria except when the milk glands are in a diseased condition. He mentions the fact as having been demonstrated by Pasteur who drew samples directly from the cistern by means of a sterile cannula. On the other hand, Bolley and Hall† compared the species of bacteria in the milk of several cows, the samples being taken through a sterile milking tube inserted into the milk cistern.

Russell‡ found that bacteria are present in the udder proper in case of mastitis. In Russell's Dairy Bacteriology we find the following: "How far these different forms of germ life are able to penetrate into the healthy udder is as yet unknown. In all probability, the glandular tissue of the udder is not affected, although it is possible that microbes might work their way up the open channel of the teat into the udder proper".

Grotenfelt§ says: "When the milk is drawn from the udder of a healthy cow it is germ free, or sterile. The original sterility of normal milk is due to the fact that the bacteria can not gain access to the milk glands from without as long as the udder is not injured in any way". F. W. Woll, the translator of Grotenfelt's work, adds in a foot note: "The bacteria in the milk cistern will be mostly washed out by the first milk drawn, but not all removed until milking has progressed some time".

Rotch‖ concludes that the few cases in which contaminated samples were obtained from the strippings, were due to faults in technique and not to bacteria from the interior of the udder.

---

* Ed. von Freudenreich. Dairy Bacteriology (1895), translated by J. R. A. Davis. Page 36.

† Bolley and Hall. Abstract in Experiment Station Record, Vol. VII., No. 11, p. 991.

‡ H. L. Russell. Dairy Bacteriology, 2nd edition, pp. 42, 43.

§ Gösta Grotenfelt. The Principles of Modern Dairy Practice, translated by F. W. Woll. Page 28.

‖ T. M. Rotch. Transactions of the Association of American Physicians (1894).

Digitized by Google

Moore* reviews the conclusions of Schultz, Gernhardt and Rotch and gives the results of his own investigations. In every examination made, he found the last milk from at least one quarter of the udder to contain bacteria. In concluding his paper, Moore suggests that a bacteriologic examination of the larger milk ducts and of the acini themselves might throw some light upon the assumption of Gernhardt. Such an investigation was rendered impossible at the time on account of his inability to procure the udder of a freshly killed milch cow.

That sterile samples may frequently be obtained directly from the teat is a fact that has been demonstrated by many investigators. But the frequency with which these same workers have failed, leads to the conclusion that the last milk contains only a few bacteria and which may or may not be contained in a given small sample. Schultz, Gernhardt, Russell, Rotch and Moore have all been unable to get sterile milk in every case. Information is not at hand concerning the amount of milk taken for a sample, except that Moore took 50 cc. of the last milk. Conn† suggests that the reason the earlier workers obtained sterile milk so readily was because they did not collect large samples. He says "Essentially the same facts have been demonstrated in regard to human milk. * * * * * Honigmann[1], Knochenstiern[2], Ringel[3], and Palleske[4], have all independently found that it is impossible to get human milk fresh from the mammary gland in such a way as to be sterile".

*V. A. Moore. Preliminary Investigations concerning the number and nature of Bacteria in Freshly Drawn Milk. Twelfth and Thirteenth Annual Reports of the Bureau of Animal Industry U. S. Dept. Agr. p. 261.

†W. H. Conn. Bull. No. 25, U. S. Department of Agriculture, Office of Experiment Stations.

1. Honigmann. Ztscher. Hyg. 14 (1893), p. 207.
2. Knochenstiern. Inaug. Diss. Dorpat, (1893).
3. Ringel. Münch. Med. Wochenschr., (1893), p. 513.
4. Palleske. Virch. Arch., 130 (1892), p. 185.

Digitized by Google

E. von Freudenreich* states that he failed to obtain sterile milk in large quantities although the udder was washed and smeared with lard, to prevent contamination. In an attempt to collect ten liters of sterile milk for an experiment in cheese making, he was unable to reduce the number below 212 bacteria per cubic centimeter. He calls attention to the ease with which a few cubic centimeters are collected, using the same precautions, but he does not recognize the presence of bacteria from within the udder.

Those who believe the last milk as drawn from the teat to be absoluely sterile, must necessarily explain the constant presence of bacteria in the fore milk. The explanation is substantially as follows: Bacteria in the air or in stable filth accidentally gain a foothold in the milk remaining on the end of the teat after milking. The favorable conditions for bacterial growth offered by the ducts favor the multiplication of the invading bacteria which increase so rapidly as to account for the presence of the multitudes always found in the fore milk. Experiments by the writer have shown that it is possible for this to occur under certain conditions, but the more probable explanation is embodied in the results of the investigations about to be described. These will be treated under three separate heads, as they have in common only the fact that they lead to the same conclusion.

THE PERSISTENCE OF CERTAIN SPECIES OF BACTERIA IN THE FORE MILK.

The work of Bolley and Hall is the only investigation on the subject that has come to notice. Samples of milk were taken by means of a sterile milking tube inserted through the duct into the milk cistern. Some species were found common to both the first and the last milk drawn. Only one organism was found common to the milk of all the animals examined, that one having no effect upon the milk. The writers conclude that a given form, once present, may be quite constant in its occupancy of the udder in an individual.

* Ed. von Freudenreich. Landwirtschaftliches Jahrbuch der Schweiz. 1890, II., p. 18.

Digitized by Google

In the investigations which I have made to determine the nature of the milk duct flora, the following methods were followed: Before collecting samples, the udder and flanks of the cow were thoroughly moistened to prevent the dislodgment of dust by the movements of milking. In addition, the teats were moistened with a solution of mercuric chloride. Samples were drawn directly from the teat into sterile test tubes which were provided with cotton plugs. In this respect the work of the writer differs from that of Bolley and Hall. Cultures were made immediately after collecting the samples. Five two hundred and fiftieths (5-250) of a cubic centimeter of milk was found, in general, to introduce a sufficient number of bacteria for convenient study upon a plate culture made in 15 cc. of medium. For a time both gelatin and agar plate cultures were made, but the use of the former was discontinued, as agar was found to be more satisfactory. The total number of colonies did not appear until after several days in the incubator at a temperature of 37.5° C. The plates were then carefully examined and sub-cultures were made from the colonies of the apparently different species. The various forms of colonies were carefully described and the number of each recorded.

The milk of each of the four teats of the cow was examined on two successive days and after a lapse of two weeks, some of them were examined upon four more days. Four or possibly five species were observed, only one being common to the four teats. Although the bacterial flora of each of the teats differed from that of its neighbors, the same species were found to persist in the same teat from day to day. They were not present in the same relative numbers on each occasion.

The milk of another cow was examined on five occasions covering a period of eight months. In the milk of this animal but three species of bacteria were found. On the first day that the milk was examined, a streptococcus was found to predominate in numbers in all four of the teats. The other two species occurred only occasionally, but in the later examinations they were found to exceed the streptococcus in number.

The presence of streptococci in milk from a normal udder is,

Digitized by Google

in the experience of the writer, unusual. None have been found in the milk of eight other cows in the same stable, or for that matter, in any examination of fore milk from cows elsewhere. The persistence of the streptococcus in the milk of the one cow is therefore of special significance.

The mathematical probability that the same organism will invade the same sterile milk duct, even twice in succession, is infinitely slight. It is therefore necessary to seek other explanation for the constant presence of bacteria in the fore milk, when we consider the persistence of species in the milk of certain cows or in particular quarters of the udder of the same cow.

AN EXPERIMENT IN COLONIZING THE CISTERN WITH BACTERIA.

With reference to determining the possibility for an organism to persist in the cistern for a considerable period, it was determined to introduce into one quarter of the udder, a culture of an easily distinguished bacillus. For this purpose *Bacillus prodigiosus* was selected because the red color of its growth on agar would render its presence in milk easily recognized when cultures were made. Four cubic centimeters of a bouillon culture were introduced into the cistern by means of a hyperdermic syringe lengthened with a milking tube. Both the milking tube and the syringe were scalded to guard against introducing any other micro-organisms along with prodigiosus. It was known from work already done that the organism in question was not a natural inhabitant of the udder upon which the experiment was being made.

The use of the milking tube as is nearly always the case, occasioned an inflammation of one side of the udder. The inflammation is attributed to the use of the milking tube rather than to *Bacillus prodigiosus*. The threatened obstruction of the teat by the accumulation of irregularly shaped masses of casein, rendered it necessary to frequently draw out the purulent liquid from the diseased quarter ot the udder during the two following days after which the inflammatory condition subsided. Plate cultures were made each day. On the day following the inoculation, ten colonies of *Bacillus prodigiosus*

Digitized by Google

appeared on the plates. Although the same amount of milk was used in making the cultures on the days following, the number of colonies was observed to decrease in number. On the sixth day, the colonies of that bacillus ceased to appear. During the whole period, with the exception of the first two days, colonies of the native bacterial flora were observed in each plate culture.

The fact that an organism selected at random, without considering its fitness for inhabiting the udder, should succeed in persisting there for six days in significant. The experiment demonstrates the fact that frequent and thorough milkings may not remove all bacteria from the udder. That other species of bacteria, better fitted for that environment are able to persist in the udder for longer periods, seems highly probable.

A BACTERIOLOGIC EXAMINATION OF THE GLANDULAR TISSUE OF THE UDDER.

The writer is indebted to Dr. Moore for the suggestion of this line of work and for the privilege of associating with him in an investigation based upon it. A partial report of the results obtained has been published elsewhere*. In attempting to draw conclusions from the facts which have already been presented, the writer finds himself unavoidably influenced by the facts brought to light in the work to which reference has been made. That his conclusions may not appear to be based upon a less firm foundation of fact than is the case, he feels justified in here referring to the joint labor.

The fundamental method underlying the investigation consisted in making a large number of cultures directly from freshly exposed glandular tissue. Sterile tubes, containing about 15 cc. each of gelatin, and some containing slanted agar were taken to the place of slaughter.

The purpose was to compare the bacteria found in the fore milk with those which might be found in the udder itself.

*V. A. Moore and A. R. Ward. Bull. No. 158, Cornell University Agricultural Experiment Station.

Digitized by Google

Samples of the fore milk and in one case, of the strippings, were taken immediately before the slaughter. In order to obtain more definite results, each quarter of the udder was arbitrarily divided into three divisions. The first (A, Pl. V.) included the teat and milk cistern. The second and third divisions (B, C) included horizontal zones of equal thickness constituting the remaining portion of the udder.

Immediately after slaughtering the cow, the udder was carefully removed. The skin was reflected and a flamed knife was used to make a dorso-ventral incision several inches in depth in one quarter of the udder. Samples of milk were collected in sterile test tubes as it welled out of the cistern and its smaller ramifications. In making cultures from the glandular tissue, care was taken to prevent milk of the ventral region from coming in contact with the freshly exposed surfaces. Bits of tissue were detached with flamed scissors, and transferred to culture media by the use of a flamed platinum loop. Tubes of gelatin and of agar were inoculated in this manner from each of the three arbitrarily designated divisions of the quarter. The same procedure was repeated with each of the other three quarters of the udder. Cultures were made from the udders of six cows in the manner described.

Upon returning to the laboratory, the gelatin was liquified at a temperature not exceeding 37° C. and poured into sterile Petri dishes where it again became solid. Agar plate cultures were made from the milk samples, and together with those slanted agar cultures already inoculated, were placed in the incubator. The agar plate cultures were designed to be used as a check upon the reliability of the conclusions reached from an examination of the other cultures. For instance: It might be possible that organisms appearing to have been obtained from the interior of the udder, may have lodged upon the bits of tissue during the tranfer. The identity in cultural and morphologic characters of bacteria found in cultures made from the fore milk and the glandular tissue of the udder would eliminate a source for false conclusions.

Digitized by Google

The tubes of slanted agar after standing in the incubator for several days, were examined particularly with reference to the presence or absence of growth. Nearly all of the media which had been in contact with material from the udder, showed growth. Note was taken of the color and character of the growth of the colonies and sub-cultures were made.

The gelatin plate cultures were in like manner examined, furnishing a more satisfactory method for obtaining pure cultures. With these, a direct comparison made it possible to trace the presence of the same organism in the three localities. In order to prove that these identities existed, sub-cultures were made for a more detailed comparison later. The plate cultures made from the milk were examined and sub-cultures were made from all of the apparently different colonies.

By comparing cultures from the various sources, it was found that the same organism frequently occurred in the fore milk and in each of the three parts of the udder. Most of the bacteria obtained in pure cultures were found to belong to one of three species of micrococci. Cultures of the three species were obtained from a sufficient variety of sources to demonstrate their general distribution throughout the udder.

The apparently healthy udders of six milch cows were in that manner found to contain bacteria in the depths of the milk-secreting tissue. By the methods employed, it was impossible to detect any difference in the relative numbers of bacteria present in the three regions of the udder.

The evidence at hand indicates that the teats and the greater portion of the udder may normally contain bacteria. It also seems highly probable that a few at least of the organisms found in the udder remain there after each milking, becoming the progenitors of the organisms found to be present in the milk when drawn. This conclusion seems to be supported by the following facts.

1. Certain species of bacteria have been found to persist in particular quarters of the udder for considerable periods of time. This controverts the statement that the milk ducts are sterile at the close of the milking, becoming tenanted from

Digitized by Google

the outside by any organisms which by chance come in contact with the end of the duct.

2. It is possible for bacteria to remain in the udder and not be ejected along with the milk. This has been proven possible in the case of one organism. A culture of *Bacillus prodigiosus* has been introduced into the milk cistern and has succeeded in persisting there for six days, as was shown by its presence for that period in the milk of that quarter of the udder.

3. Cultures of bacteria have been obtained by Dr. Moore and the writer from the glandular tissue of the udders of freshly killed milch cows. Identical species of micrococci were obtained from the milk and from the glandular tissue of the udder.

4. It has not been shown by the investigations published up to this time that the last milk drawn is always sterile.

From the Laboratory of Comparative Pathology and Bacteriology, New York State Veterinary College, Cornell University, Ithaca, New York.

Digitized by Google

Digitized by Google

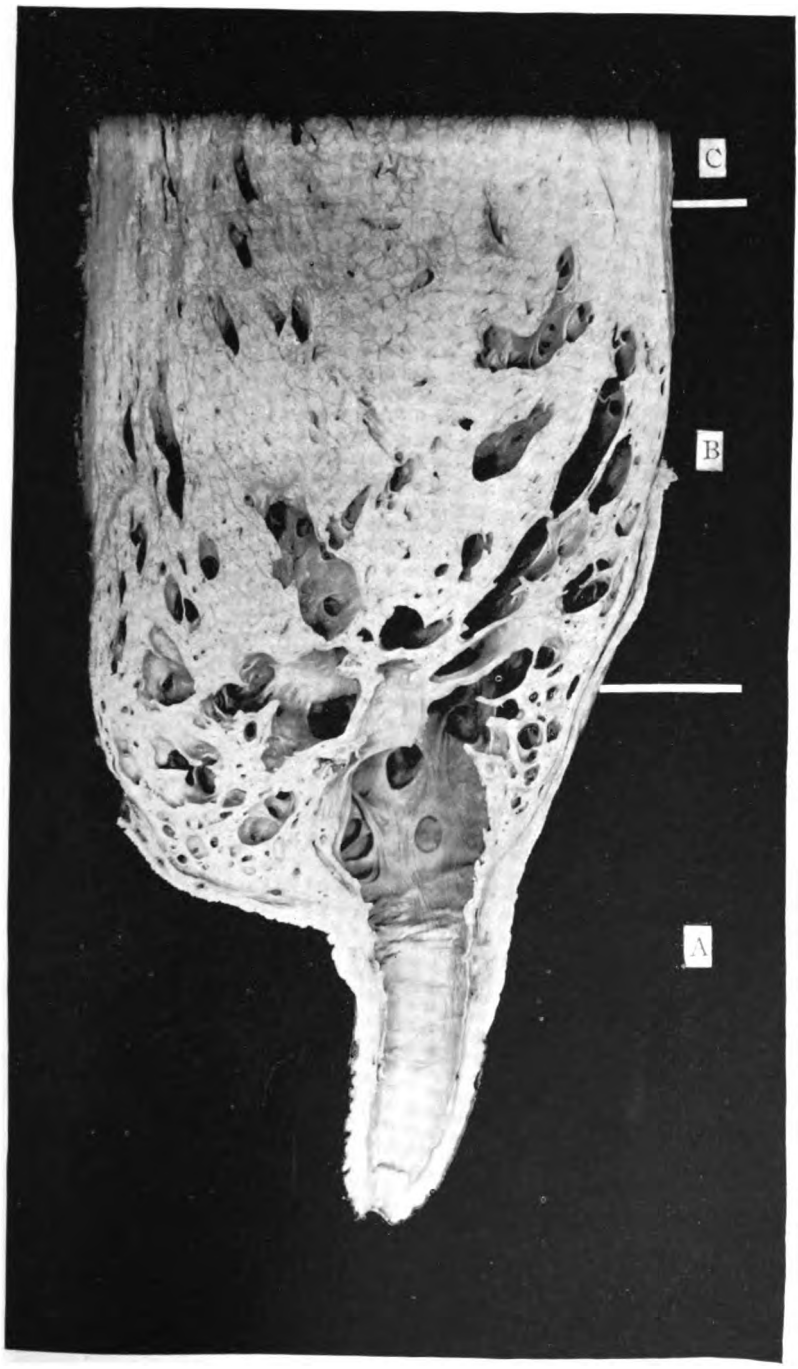
PLATE V.

A photograph of a section through the teat and one quarter of the udder of a cow. The parts represented by the letters *A*, *B*, *C*, indicate the three arbitrary divisions into which the gland was divided for purposes of examination.

From Bulletin No. 158, Cornell University Agricultural Experiment Station.

Digitized by Google

PLATE V



Digitized by Google

Digitized by Google

AN OCCURENCE OF ALBINO EGGS OF THE SPOTTED SALAMANDER, *AMBLYSTOMA PUNCTATUM* L.

HORACE W. BRITCHER, SYRACUSE, N. Y.

The folowing account could not have been written at all except that Dr. C. C. Mercer kindly placed at my disposal the facilities of the Medical College, and that Prof. C. W. Hargitt gave me access to literature on the subject.

About the middle of last March, while searching for amblystoma and frog eggs, several small masses of white eggs were found. As they were supposed to be unfertilized and already decomposing, only one mass was brought to the laboratory, where an examination under the microscope showed the eggs to be developing regularly, the surface presenting a network of cells normal in all respects except that there were no pigment granules present. A day or two later the remainder of the eggs were obtained (about 100 in all), and various stages in their development have been preserved for study.

All of the growth phenomena proceeded apparently regularly, the egg lengthening, neural folds forming and closing, the gill ridges and tail appearing and finally life being manifested by the twitching of the body when the jelly mass was disturbed. Just at this stage there began to be noticable to the naked eye a slight grayish mottling of the sides of the body. This pigmentation increased as the tadpoles grew and when they had reached a length of about eighteen mm. they could not be distinguished, by the naked eye, from normal embryos raised in dim light in the laboratory, but were a little lighter in color than embryos freely exposed to the sunlight.

An examination of the preserved material shows that in none of the stages are there present any brownish black pigment granules. Embryos about six or seven mm. long show, just along and above the midline of the side of the body, many small, angular, dark spots, quite uniformly scattered along a band about one-quarter as wide as the dorso-ventral diameter

Digitized by Google

of the body. In an embryo ten mm. long the spots have increased considerably in number, spreading both dorsally and ventrally, and have sent out numerous branches which in many instances anastomose freely. One mass of such spots is seen just in front of the gills, another just behind the gills, while those along the side of the body dorsal to the midline are mainly disposed in four groups. Those ventral to the midline are more uniformly distributed. A few spots are present on the gills and a few are found in the tail region of the dorsal fin. In an embryo thirteen mm. long the branches anastomose much more freely, and the head, before nearly spotless, has become thickly covered. At fifteen mm. the spots are fusing together in numerous instances.

The surface of normal eggs is black or dark brown in color, and as the embryo grows it continues quite uniformly dark brown (except ventrally) for some time, becoming finally in embryos twenty or more millimeters long a grayish black color. In a normal embryo nine mm. long this uniform brownish color is seen to be augmented along the sides by darker patches composed of the black branching pigment spots, which in an embryo twelve mm. long have spread quite freely over the surface.

Pigment in the salamander larva has been recognized as occurring in three ways: first, as minute brownish-black spherules in the epithelial cells; second, in branching pigment cells with processes passing between the epithelial cells; and third, in the ramified pigment cells of the cutis. In this paper no distinction is made between the second and third classes.

The surface pigmentation of the normal egg is of the first class and a section of such an egg when the epiblast is several cells deep, shows the outer layers of cells to contain large quantities of such granules, chiefly massed near the free surface of the cells, but extending also inward, mainly along the cell wall. Similar pigmented granules are distributed less abundantly over the free surface of the cells lining the mesenteron, and also to some extent are present in some of the yolk cells lining the blastocoel.

Digitized by Google

Sections of a normal tadpole thirteen mm. long show the surface epithelium to be granularly pigmented as above, but the granules are more compactly arranged in a layer close to the surface. Just beneath the epidermis the branching pigment cells are numerous, the branches extending usually parallel or obliquely to the surface; at places in the tail they appear to form almost a continuous layer. In the gills the branches ramify more freely among the surrounding cells. The ear and nostril invaginations are quite deeply pigmented by the brownish black granules; the pigmented layer of the dorsal portion of the retina is composed mainly of the subepidermal branching cells, while the ventral portion seems to derive its color from the pigmented granules. The cells of the nervous system contain numerous rounded black pigment bodies, which are present to a lesser extent throughout the mesodermal cells of the body.

In a tadpole eight mm. long, the subepidermal, branching pigment cells are not so abundant nor so fully developed as in the larger individual. There are rounded pigment bodies in the mesoderm, but not in the nervous system, which is colored brownish by the pigment granules. The pigment of the retina of the eye seems to be of the epidermal granular nature, rather than of the subepidermal cellular character.

Sections of an albino embryo with closed nervous system show no traces of pigmentation whatever, either granular or cellular. Sections of an embryo six mm. long show subepidermal pigment cells appearing, but there are as yet no traces of pigmentation in the eye or ear invaginations.

In a tadpole ten mm. long the subepidermal pigment cells are much more numerous than in the previous stage and are branching out in all directions more freely than those in the slightly older stage of normal embryos. The ear invaginations are entirely devoid of pigment but the retina is being pigmented dorsally and downward along the back of the optic cup, probably by the branching pigment cells. The lower side of the retina is not yet pigmented, and in the adjacent subepidermal tissue there are only two or three pigment cells in the

Digitized by Google

neighborhood of each eye. The cells of the nervous system and also those of the mesoderm throughout the body are without any traces of the rounded pigment bodies so numerous in the normal embryo.

A SHORT LIST OF PAPERS BEARING MOST DIRECTLY UPON THE SUBJECT

CAMARANO, LOR.: Di alcuni girini albini e delle cause dell' albinismo. Boll. Musei Zool. Anat. Comp. Torini. T. 4, No. 64.

FISCHER-SIGWART, H.; Sur l'albinisme chez les larves de *Rana temporaria*, avec quelques remarques sur l'albinisme en generale. Verhandlgn. Schweiz. naturf. Ges. Soloth, 1888, p. 59.

LESSONA, MICH.: Dello albinismo nei girini della *Rana temporaria* L.: Atti. R. Accad. Sc., Torino. Vol. 16, Disp. 1, p. 94,

FISCHER, A.: Uber Beeinflussung and Entwickelung des Pigments. Arch. f. mikr. Anat. Bd. 47, Hft. 4, p. 719.

FISCHEL, A.: Pigmentation of *Salamandra maculata*.
(Abstr. in Jour. Roy. Micr. Soc. 1896, p. 611.)

WINKLER, F.: Origin of Pigment in *Bufo*. Mitth. Embryol. Inst. K. K. Univ. Wien, 1892, p. 64.
(Abstr. in Jour. Royal Micr. Soc. 1896).

Digitized by Google

Digitized by Google

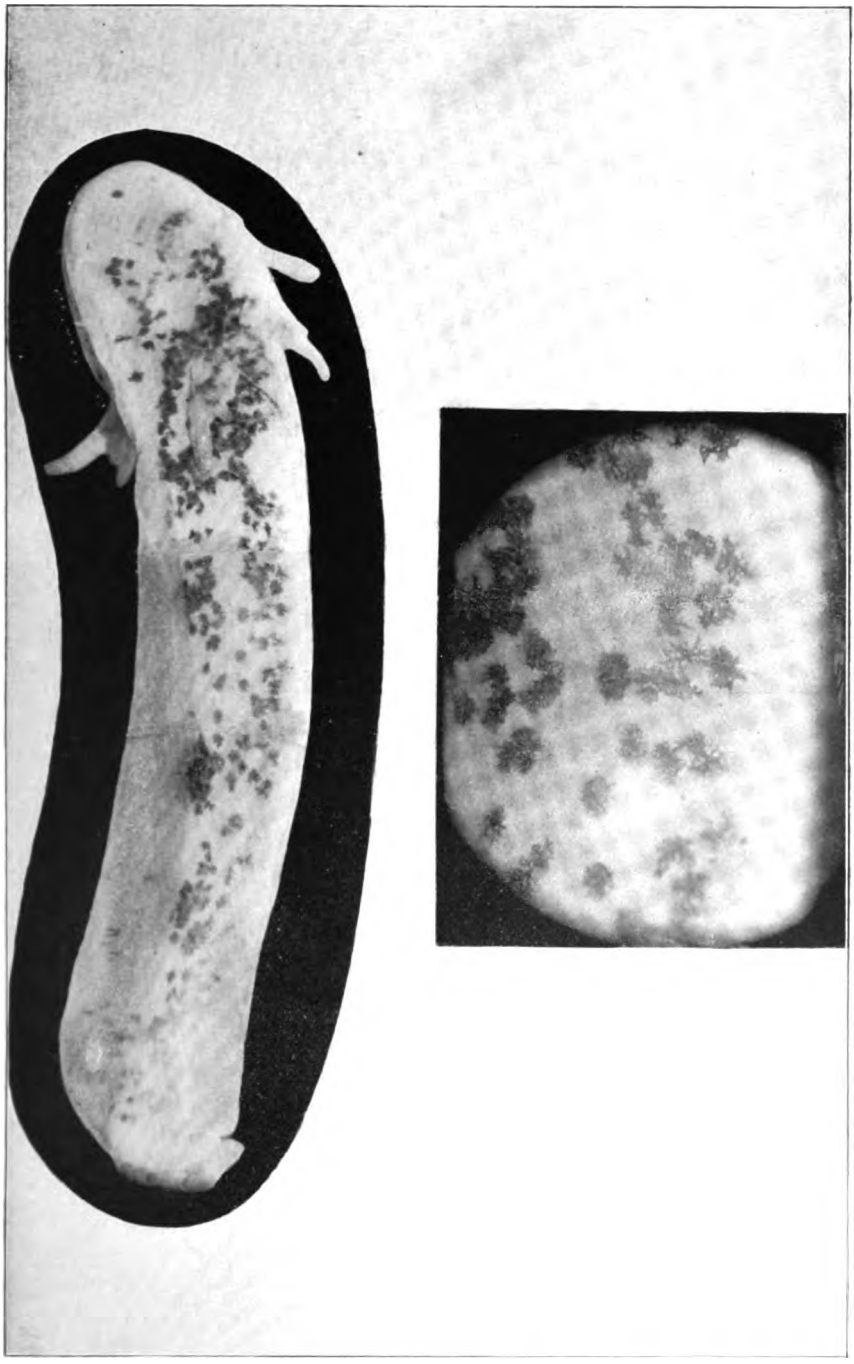
PLATE VI.

Fig. 1. Photomicrographs of *Amblystoma punctatum* 10 mm. long, matched to show distribution of branching pigment cells.

Fig. 2. Portion A–B of Fig. 1, more highly magnified to show character of branching pigment cells.

Digitized by Google

PLATE VI



Digitized by Google

Digitized by Google

EXPERIMENTS IN FEEDING SOME INSECTS WITH CULTURES OF COMMA OR CHOLERA BACILLI.

R. L. MADDOX, M. D., HON. F. R. M. S.

On looking over some old slides lately a few were found that related to the results obtained by experiments, made at two different periods in the year 1885, on feeding flies and other insects with cultures of living comma or cholera bacilli. Some of the mounts had been spoiled, being overrun by mycelial thread, the specimens having been mounted dry. Some of the specimens had been lightly stained, others were unstained. As none had been figured or photographed, it occurred to me that three or four, if reproduced, might yet be of interest, if they were utilized to illustrate a very brief résumé of the two articles published in the numbers for August and December of the Royal Microscopical Journal of the same year. Consequently four of the slides have been selected to illustrate by photomicrographs the following remarks:

The object with which the experiments were undertaken was firstly to ascertain if the comma bacillus was pathogenic to insects when fed in ordinary or diluted cultures on sugar; secondly, to note if the dejecta contained any of the bacilli in a liviug state; and thirdly, to find out if cultures could be made from such excreta.

Of course it was necessary to see microscopically if the ordinary dejections contained any curved bacilli. This was done by retaining such insects in captivity for some time before being fed with the cultures. These cultures, which were originally in agar-agar and gelatine media, had been very kindly given to me by Prof. E. Klein, F. R. S. Wasps, bees, *Eristalis*, the black beetle and the common blue-bottle were chiefly used in the experiments. The bee had to be discarded, as curved bacilli had been found in it by Mr. Cheshire, though I had not noticed any in the evacuations. One wasp was retained

Digitized by Google

in captivity some time, and seemed to me to be considerably affected by the food, but as two of the four illustrations refer to the blowfly, which is fairly hardy in captivity, one being set at liberty after forty days confinement, and fed for many days on the cultures, the remarks will refer chiefly to that insect.

For the main particulars of the experiments I beg to refer to the aforenamed articles in the Royal Microscopical Journal. The insects were generally captured by placing a prepared tumbler over the insect, and then sliding stiff paper or cardboard beneath and transferring the vessel to a clean and shallow saucer or plate of glass on which a square piece of glass was placed. This served to collect the dejections passed on it, and was easily removed to substitute another on which a small lump of sugar, dampened with the culture, sometimes diluted, was afterwards placed. The microscopical examinations were made after scraping up the excreta passed at various periods extending even to thirty-six hours and comprising thirty-one dejections, by a flattened needle, and mixing them with sterilized water on a cover glass. There was one difficulty originated by this plan which I fancy led to many of the experiments being abortive, as many of the dejections were dried up, and the contained bacilli probably dead, or killed sometimes by the high temperature.

Before touching the details it may be as well to state that Dr. Grassi found in 1883 that flies which had fed off the ova of *Taenia solium* that had been kept in alcohol, passed dejections containing the ova; also that others which had fed off the ova of a *Tricocephalus* from a plate in the laboratory, carried and deposited the ova on pieces of paper placed in the kitchen. Dr. Grassi also found they could be carriers of the ova of the thread worm, *Oxyuris*. I think that lately experiments have been made of a more extended nature in the same direction with the plague bacillus, but unfortunately I have no data to refer to. N. Davaine had also found that flies carry the contagion of infected blood, consequently my experiments only added another possibility to the list. I found that *Eristalis tenax* supported captivity fairly well, and as it breeds in sewers expected, it might possess advantages for these experiments; but

Digitized by Google

this was not the case, so the common blue-bottle fly was selected as the best, and the following remarks will apply chiefly to this insect, It may however be stated that the natural dejections of the *Eristalis* contained no curved rods, and after feeding on the cultures, only very few were seen in the evacuations. The cultures placed on aniline dyed sugar did not seem to particularly affect them, except to increase the oily globules in the stools. Some were allowed their liberty, while others were killed to examine the perivisceral fluid, when by staining many pale, motionless rod bacilli of four or five joints were noted, also a few rather large rods, but scarcely a curved bacillus could be found.

A female blowfly placed in captivity was firstly fed with sugar moistened with a watery solution of methyl violet for six days, and then seemed extremely feeble. It was then fed on sugar damped with a gelatine culture which though much broken down, contained an abundance of commas, but fearing it might be unsuitable, I changed for an agar-agar culture not broken down. The fly at first fed freely on this, but later a male blowfly was also placed under the same tumbler. Both, after feeding off and on for six hours, furnished together six dejections. These, though much dried, furnished well marked, double or S-shaped bacilli, but without movement. The next day the flies were seen in coitus, and a little later the female was found dead. In the perivisceral fluid scarcely a comma could be found. The male was now kept by itself and fed from the original agar-agar culture. The daily examinations of the dejections did not lead to much, until about the seventh day a fair number of the crooked rods were passed, some with a very sluggish motion, but short and dumpy in appearance. A day later, 18 dejections had been passed in the 24 hours; these contained little colonies of the commas, as well as single and double shaped ones. The perivisceral fluid of this fly was also examined, and in upwards of fifty fields only four curved bacilli were found. It is just possible that the few curved bacilli found in this fluid might have been carried in by the scissors used to make the incisions into the integment.

Digitized by Google

Another female blowfly was now made the subject of further experiments, as no commas were found in the normal dejections. It was fed on sugar damped with the agar culture that had been inoculated with prepared meat infusion (note Plate VII., Fig. 2). Curved bacilli being found in the dejections, some motile, an inoculation was made into a prepared meat infusion kept at 90° F.; on the fourth day in four excreta thirty crooked bacilli were found, but three days later scarcely one could be seen. The culture was changed for another similar four days old and used to inoculate a fresh meat infusion, as the former was accidentally upset. This fly was sadly weak on its legs but strong on wing. This fresh culture was used to moisten the sugar. The fly feeding from it freely, passed three liquid dejections only part of these were used to inoculate a clear meat infusion, which gave turbidity after thirty-two hours and yielded both long and short undulating rods, with only a few single commas, which a weak solution of aniline acetate rendered very clear. The fly, although much revived, could not crawl to the top of the tumbler, hence it was fed from the agar culture, and in two days thirty-one dejections were passed; they contained only a few curved rods, but the mixed dejections were used to inoculate a gelatine tube, as I had not yet succeeded in inoculating gelatine from the excreta. The tube was kept at room temperature 65° Fahr.

Two days later there were fourteen evacuations semi-solid and one fluid; seven of the former were mixed with half of the latter and used to inoculate another gelatine tube. The other seven and half were inoculated into another gelatine tube which was then heated to fluidity and poured out on four sterilized 3x1 slides, covered and kept at room temperature. On the third day these were examined and only one furnished amongst other growths the comma bacilli. The gelatine tube with the seven and half dejections had on the third day a whitish raised warty-looking growth with no evidence of the track of the needle. This contained crooked rods of all degrees of curvatures even to a complete ring (vide Plate VII., Fig 3).

Digitized by Google

An inoculation into meat infusion from the same agar-agar culture when examined was found to abound with similar organisms. This was transmitted through the fly; at first no curved rods could be found in the dejecta, but later on they yielded a fair number of comma bacilli. After seven days the fly was fed from the meat infusion culture, and passed some of the crooked rods; these were inoculated into a fresh meat infusion and in three days gave an abundance of bacilli, some in zooglœa masses, others free and motile.

The fly had now grown very weak, hence it was fed on plain meat infusion, on sugar, on fruit jelly and other things, and quickly regained strength. After having been in captivity forty days, it was given its liberty as no rods were longer found in the dejections. These experiments, troublesome as they were, show I think conclusively that the comma bacillus can be revived after passing through the digestive organs of the blow-fly, but if the dejections be dry, or the rods weakly or scanty, there is no great chance of a revival by the contamination of food, yet if fairly abundant, of strong growth and not too dried up, they may be able to spread disease.

Digitized by Google

PLATE VII.

Fig. 1 represents the comma bacilli in the original culture on agar-agar which has a very rough and crowded aspect.

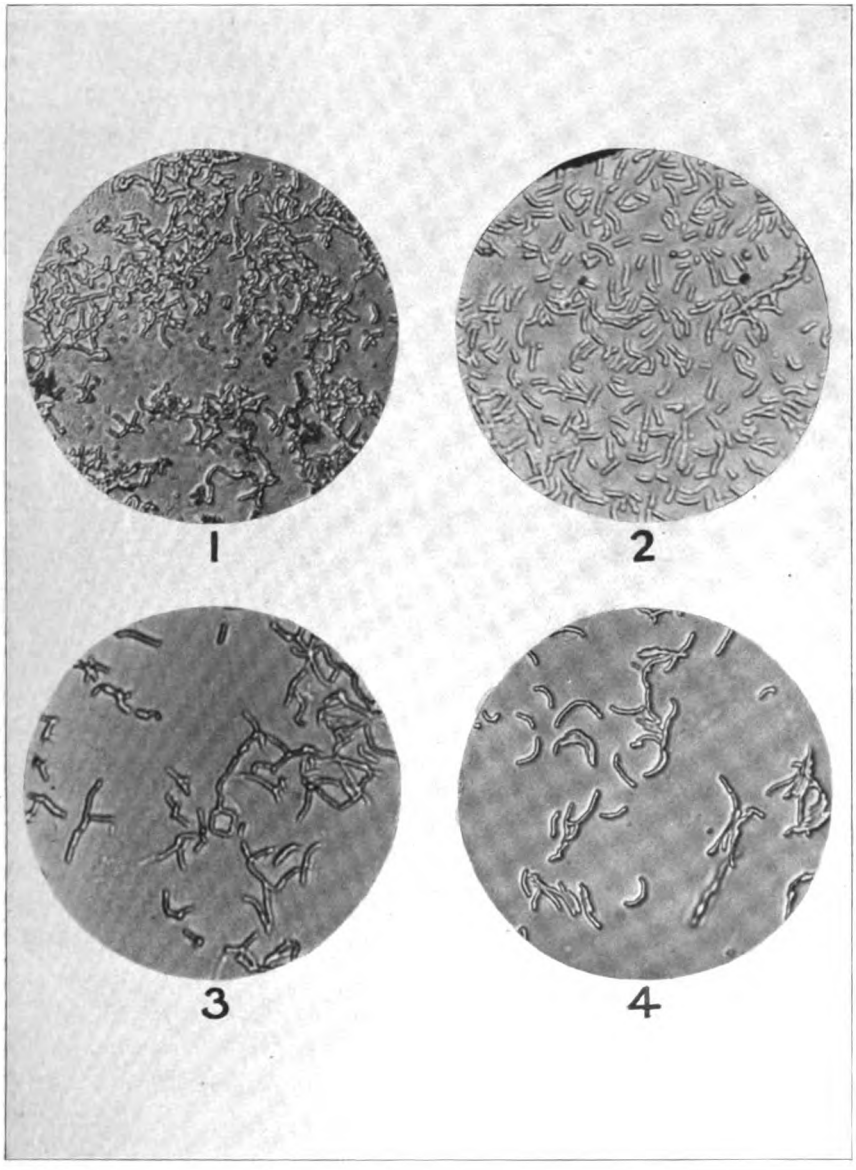
Fig. 2 is taken from the same culture inoculated into prepared meat infusion (Liebig extract) and shows the bacilli in a more favorable condition.

Fig. 3, from an inoculation from the dejecta into gelatine, affords an example of some of the bizarre forms found in comma bacilli cultures.

Fig 4 is from an inoculation of the excreta into meat infusion, and likewise furnishes examples of irregular forms. A field was selected in which there appeared a double comma, the smaller one being apparently embraced by the larger one, a small opening being left between them, and what looks very much like a spore in the negative lying to the left of the interspace. The bacilli after transmission through the fly appear to have gained a little in size. The negatives were made at the magnification of 1000 diameters.

Digitized by Google

PLATE VII



Digitized by Google

Digitized by Google

QUESTIONS IN REGARD TO THE DIPHTHERIA BACILLUS.

M. A. VEEDER, M. D., LYONS, N. Y.

There is no longer any question in regard to the identification of the diphtheria bacillus. That has been settled beyond dispute. There is much to be learned, however, in regard to its varieties, and their behavior under different conditions in and out of the body, and in association with other micro-organisms, as well as when present alone. For the purpose of such study there are two methods, each of which should supplement the other. These minute forms of life become known to us, not only as they appear under the microscope, but also by the behavior of the diseases which they produce. Thus the questions that force themselves on our attention during an epidemic become a guide for further microscopical study, and it is for the most part questions encountered in this way that it is now proposed to mention.

A very important question is that of the life history of the bacillus in the human throat under various forms of treatment, and without treatment. Since it has become customary with health boards to make the duration ot quarantine depend upon the results of microscopical examination of cultures of bacilli from the throats of those having the disease and those exposed, there has been a tendency to concentrate attention upon this mode of propagation from individual to individual. There is no doubt that so long as the bacillus is present, even in the absence of all clinical symptoms of diphtheria, there is danger of conveying the disease, and measures of throat disinfection, and immunization of the person, and quarantine, should be persisted in until it is certain that all danger is past. Attention to detail is important in this connection. Disinfectant

Digitized by Google

solutions for use in the throat require to be rightly applied at sufficiently frequent intervals, and in such manner as to reach behind the palate and into the back of the nostrils, or they will fail no matter how well adapted by their chemical and physical properties to destroy the bacillus. In like manner the antitoxin, if used for purposes of immunization, requires to be of proper strength, and given early. It is safe to say that without the use of such measures, and quarantine of proper duration, diphtheria will inevitably spread. But even when these precautions have been employed thoroughly they may fail to eradicate the disease from particular localities. In other words the growth of the bacillus in the throat, whether in typical or atypical forms, does not account for the manner in which diphtheria sometimes remains endemic in a particular household or neighborhood in spite of quarantine and throat disinfection. A very notable instance of this sort was reported at the Montreal meeting of the British Medical Association last year, and again at the American Public Health Association at Ottawa this year. In this case diphtheria has continued to recur in a state school in Minnesota at frequent intervals for ten years in spite of the most elaborate precautions. In the British Medical Journal for April 16th, 1898, at page 1009, it is stated that an atypical variety of the diphtheria bacillus, supposed to be the cause of the trouble in this school, was found to be confined strictly to inmates of the institution, with one exception in 2400 examinations. In other words there was no endemic prevalence of anything of the sort in the town adjacent, or anywhere else in the state, so far as was known, except in this particular school. Presumably antitoxin, throat disinfection, and quarantine, were all employed with thoroughness commensurate with the interest that such a state of affairs, and its wide publication, would arouse, and yet the disease continued to recur.

It would seem evident in such a case that there must be some other method of propagation of the bacillus than in human throats, and that the culture medium, whatever it may be, must be located somewhere on the premises, harboring and

Digitized by Google

perpetuating the infection so that when destroyed within the body of every inmate, reinfection from without becomes possible again. The growth of the bacillus in media external to the body might very well originate atypical forms. But be this as it may, the writer as health officer and practising physician, has repeatedly been brought face to face with this very question as to the life of the diphtheria bacillus outside the body. As a rule when the disease has given evidence of a tendency to recur in a particular house or neighborhood it has been possible to find somewhere about the premises an accumulation of material obviously adapted to serve as a culture medium for this particular bacillus, and so situated that effluvia from it would surely gain access to those very persons who contracted the disease.

In any such case it is, as a rule, difficult to secure pure cultures of any particular bacillus that may be in question. The varieties present are more numerous than in the cultures from the throat so that the one wanted is lost in the crowd, and there may be admixture of much extraneous matter, if direct inoculation of the culture medium is attempted, so that it is difficult to get conclusive evidence. Thus far the best evidence attainable has been the immediate and complete disappearance of the disease, when the proper source of the trouble has been identified, and effectual measures for its removal by disinfection, or otherwise, have been adopted.

Still it is possible that definite information in regard to the life of the bacillus outside the body may be had experimentally. It should be determined for what length of time the bacillus remains alive not only in a single culture, but also in a succession of cultures, transferred from one to another. This may be done with the various media ordinarily employed for such purposes, or with saliva, or pus, or mucus, or other secretions from the body, under varying conditions of temperature and moisture. Thus the development of atypical forms and changes in the virulence of the bacillus due to its mode of life outside the body may be detected by such a succession of cultures starting from a single one.

Digitized by Google

This is the laboratory side of the question, as yet unworked, except in desultory and fragmentary fashion. Leading up to it from the side of the practical work of the health board, is the identification of such culture material, and its proper disinfection, or destruction. In the experience of the writer a drain pipe that is rarely if ever flushed completely, and that is crusted over on the inside with partly dried filth is specially apt to form a medium for the retention and growth of successive crops of the diphtheria bacillus. Inoculation may occur in various ways, a little expectoration, rinsing the mouth at the kitchen sink, for example, may start the process. The bacilli implanted in an underground drain, or other receptacle that is constantly nearly dry, and never completely flushed, find these conditions very suitable for their growth. The temperature and moisture, and fresh accessions of organic matter from day to day are well adapted to bring about a series of cultures resembling substantially those from tube to tube suggested in the last paragraph. In such a case disinfectant solutions may run along the bottom of the drain leaving the top and sides untouched. Indeed in the case of a very large drain of this sort the writer found it necessary to generate chlorine in order to disinfect it completely. During continuance of infection there is constant liability of its diffusion by the partly dried material becoming detached and carried by the vapors arising from fermentation, or by access of air currents. An instance of this sort that came under the observation of the writer was in connection with a dry closet system, so-called, in a school building. The vaults containing the partly dried excretions were in the cellar, and were cleaned only once or twice a year and never disinfected. Under these conditions an outbreak of diphtheria among the children appears to have been brought about by this material in the cellar becoming infected perhaps by particles of partly dried mucus containing the bacillus being carried down through the ventilating flues which were built so as to pass through these vaults. Infection once accomplished propagation of the bacillus on a large scale would ensue on the plan of plate cultures, there being accessions of fresh material

Digitized by Google

suitable for the purpose daily. This being the case it would need only some failure of the ventilating apparatus to allow the vapors arising to find their way into the rooms most distant from the main ventilating shaft and it was in these rooms precisely that the disease occurred and spread. An effort was made in this case to secure cultures, but the difficulty was that the bacterial flora was too abundant, and the particular bacillus sought was lost in the crowd, as in other experiments of the kind with drain pipes and receptacles having the peculiarities indicated.

A very important point in connection with such prevalence of diphtheria as has just been indicated, is the occurrence simultaneously of much ordinary sore throat so-called, in which the usual form of the diphtheria bacillus appears to be wanting. It has occurred to the writer that some atypical variety of the bacillus, of greatly attenuated virulence, through an succession of cultures outside the body, may be responsible for this form of throat trouble, often spoken of at such times as sympathetic sore throat. I would regard this form of the disease, in connection with an outbreak of diphtheria, as clear evidence that it was becoming endemic in the locality; in other words that cultures outside the body were in progress somewhere in the vicinity.

Mixed infection, or the association of diphtheria bacilll with steptococci and other micro-organisms, is of great interest because of the increased danger to life, and because it may serve to explain at times the failure of the antitoxin which does not protect against other toxins than that of diphtheria. But these are points of interest to the practicing physician rather than the microscopist.

The fact that diphtheria, like many other diseases, spreads in waves over extensive portions of the earth's surface, increasing very largely for a year or two, and then subsiding for a series of years, is usually referred to meteorological conditions modifying the virulence of the bacillus itself, or modifying the conditions on which its virulence depends. It may, however, be a question for study by the methods of modern microscopy.

Digitized by Google

It is possible that the products of bacterial activity may inhibit the growth of these organisms, in and out of the body, on a scale large enough to be evident at a glance in the statistics showing their epidemic prevalence. In other words even when practically left to themselves, as is the rule in many parts of the world, they do not increase indefinitely but exhaust the material susceptible to their attack, and perhaps in a measure originate their own antitoxines. In either case it is a question to be determined by the culture methods of the bacteriologist and microscopist, identifying atypical and modified forms of the bacillus, and their relation to the severity of the disease in particular cases, and its epidemic prevalence in general.

Another exceedingly interesting series of questions is as to why the bacillus attacks children in preference to adults, and certain tissues and parts of the body in preference to others. Considerable light has been thrown upon these very difficult and obscure phases of the subject by modern methods of study of embryology and comparative anatomy, bringing out what may be termed the developmental relations involved. This is the special field of the histologist and microscopist, and it is likely to be exceedingly fruitful in the near future. Comparative pathology is the outcome; this is just beginning to be recognized as a part of the medical curriculum and is likely to answer many questions along the lines just indicated in this paragraph.

Digitized by Google

MEDICAL MICROSCOPY.

A. A. YOUNG, M. D., NEWARK, N. Y.

Microscopy may be termed one of the eyes of Medical Science, valuable when rightly used and its revelations rightly interpreted. The novice sees the same objects that the skilled microscopist sees through his microscope but to the novice the characters seen are unintelligible hieroglyphics while to the microscopist these same hieroglyphics become an intelligible written language. Microscopy is only valuable to those whose eyes have been trained and prepared to differentiate objects found in the microscopic field, and a mind so educated along certain lines as to be able to resolve the impressions received into an intelligible language.

It is not enough to know that objects in the microscopic field stand out in bold relief to the eye, their outlines easily recognizable; they must also form a definite concept in the mind of the observer or nothing is gained practically to the observer or to the world.

From time almost immemorial it has been considered that abnormal conditions of the body were produced by morbific agents having at least a quasi-independent existence, whatever the morbific agents might be. Here, too, evolution has done its work, it has carried the medical profession along from the personal and unknowable "little devil" supposed to abide with man, to the tangible and recognizable bacillus which the microscope has now forced from its obscurity.

Though bacilli belong to the lower forms of organic life it cannot be said that they originate from nothing. It seems to be a well established fact that there is no such thing as "spontaneous generation" but that each living thing must produce

Digitized by Google

after its kind, and so far as we are able to study material forms this is absolutely true; but of the beginning of life, or life itself, outside of its physical manifestations, He who called it into existence has ever maintained an absolute silence and thus, for some wise reason, has He left humanity on this subject in intellectual darkness. What life actually is therefore must be left to individual surmises.

The germ theory of disease was promulgated long before the discovery of the disease producing bacillus, and over this theory many hard battles were fought before it become an accepted fact; so well is it now grounded that its verity scarcely admits of a question.

The microscope in medical science has indeed become a most valuable adjunct; it has pointed out the way from the field of fancy to the field of fact, it has made the hypothetical bacillus a veritable bacillus, it has by its revelations, in a measure at least, revolutionized the methods of the medical profession and the end is not yet.

If the known be indicative of the unknown, if the past be prophetic of the future, we are forced to the conclusion that all of those abnormal manifestations of the body which we term disease must be due to the presence of bacilli or rather of developing bacilli within their nidus or within some developing medium of the body. It is important also for the physician to understand not only how to search for the specific bacillus and recognize it full grown, but he should know equally well where its natural home is, what its method of reproduction and what elements are necessary to carry out its reproductive processes.

The process of development as observed in the macroscopic world clearly indicates that it is during this developing period that the growing being preys upon and is most destructive to other forms of life; this is markedly true in the insect world, it is the larva and not the imago that is destructive to organic life. The mánner and mode of living of the larva differs widely from the imago towards which it is progressing and into which it will in due time reach its perfectness. What was

Digitized by Google

food for the larva in its developing stage becomes to the imago positively repugnant and unfit to sustain its life. What is here true in the macroscopic world is inferentially true in the microscopic world. The developing bacillus may require different surroundings and different dietetics from the fully developed bacillus; it may also be true that the fully developed bacillus is perfectly harmless unless it be aroused and its reproductive function brought into activity, which function it certainly has, and having such a function there must exist in or about it at least a germinal vesicle or spore in which the beginning of life takes place. Such a vesicle must exist though the eye hath not seen it; it is no proof that an object does not exist because it has not been discovered. Ultimate particles will in all probability remain theoretical ones and defy detection though their existence cannot be doubted.

It seems to be an established fact that protoplasm is the basis of all animated matter and in it began the first manifestations of that mysterious force known as life, the manifestation of which has developed physical man. There seems to be a unity in creation, and coming as it must from one Creative Mind, it could not consistently be otherwise.

What is so manifestly true in insect life must also be true, though not apparent, in every animate thing having prehensile and reproductive powers. The bacillus, coming as it does under this classification, must have a beginning in a germinal vesicle, a period of activity, of growth and development, ending in perfectness then giving its individual life to other germinal vesicles which it has developed and prepared to deposit in some developing menstrum to complete again another cycle.

That the home of the fully developed bacillus is not the home of the developing one, and that the conditions surrounding the former are markedly different from the conditions surrounding the latter are practically proven by recent investigations in the biological history of the typhoid bacillus and by the action of the antitoxic serums in the system.

It is true, as observation has proven, that the presence of fully developed pathogenic bacteria in or about the system

Digitized by Google

does not constitute disease even though located upon those membranes on which they are found when pathological processes exist. It is then confidently asserted that when these pathogenic bacteria enter some of the body-juices either as fully developed bacilli or as spores from them, and the process of reproduction begins, then, and then only, do we find the phenomena that are indicative of those abnormal processes that constitute disease.

One of the greatest needs of the medical profession of to-day is a more accurate knowledge of the *biology of bacteria.* On account of the difficulties that arise in methods and technique the busy physician is unable to enter upon and bring to a successful termination the necessary investigations; such investigations call for the services of an expert. For such services the medical profession as a body must appeal to the microbiologist and it is confidently hoped that such appeal shall not be in vain.

Digitized by Google

AGAR-AGAR.

W. W. ALLEGER, WASHINGTON, D. C.

The preparation of agar by the older methods is well known to be a tedious operation, which consumes much valuable time. The product obtained is seldom, if ever, quite transparent; while not infrequently troublesome precipitates which not only mar the appearance of the medium but render it unsuitable for the finer classes of work, develop after sterilization.

The use of powdered agar, which has been in the market for two or three years, because of its ready solubility, simplifies the process and greatly shortens the time required in the preparation of the medium; but for some reason, doubtless because of the scant notice which has been given to the matter in the literature, it does not yet seem to have come into general use. To call attention to the powdered form, and to report a method for obviating the appearance of secondary precipitates in the tubes, on sterilization, was the object of a paper by the writer published in the first number of the Journal of Applied Microscopy.

The method then described materially lessened the time and labor required in the preparation of agar and gave a perfectly transparent product. Subsequent efforts, aided by a suggestion obtained from an article by Dr. Ravenel, in the June number of the Journal, have enabled us to shorten the time limits from two and one-half hours to one hour, counting from the time of the receipt of the meat in the laboratory until the last drop of the completed medium has passed through the filter, and yet obtain average results; while by deferring filtration until after the first sterilization a perfectly transparent medium is obtained. In the latter event from half to three-quarters of an hour suffices for the initial preparation, exclusive of the time required for

Digitized by Google

sterilization in bulk, but a half hour more is required on the following day for re-heating and filtering. The process is as follows:

Rub up 10 grams each of powdered agar and Witte's powdered peptone, and 5 grams of sodium chloride, in a porcelain-lined saucepan, with just sufficient water to thoroughly moisten the powder and form a thin paste; add gradually, while stirring the mixture, 500 cc. of water; place on a gas stove, interposing a piece of asbestos board or wire gauze between the saucepan and flame, and heat the mixture until the agar is dissolved, stirring occasionally to prevent burning on the bottom of the dish. If the paste made with cold water is properly rubbed up, so as to break down all the lumps and moisten all the agar, solution will be practically complete by the time the boiling point has been reached, so that two or three minutes brisk boiling suffices.

With the aid of a meat press extract the juice from 500 grams (one pound) of lean meat, and add the juice to 500 cc. of water. Mix this "flesh-water" with the agar solution—which now should have cooled sufficiently not to coagulate the albumin in the flesh-water, but still be hot enough to remain fluid—and carefully neutralize with a 4 per cent solution of caustic soda.

After neutralization boil the mixture until all the coagulable albumin in the flesh-water has been coagulated and comes to the surface, leaving a clear fluid beneath. Again test the reaction, and, if need be, correct it; add sufficient boiling water to supply any loss that may have occurred through evaporation, and filter through paper. To insure rapid and complete filtration without the necessity of reheating the mass I distribute the solution in three or four filters, using coarse, folded paper, pass sufficient boiling water through each filter to wash away loose lint and thoroughly heat the funnels just previous to commencing the filtration of the agar. With good paper and proper attention to detail filtration is usually accomplished in from ten to fifteen minutes.

While filtration is in progress sterilize or boil a tube of the filtrate. If it remains clear after heating, and when cold is free

Digitized by Google

from sediment and only slightly opalescent, the entire filtrate may be immediately run off into tubes and sterilized. But if a precipitate should make its appearance either on heating or while cooling, the filtrate should be sterilized in mass and allowed to stand in the sterilizer with the light turned low or out until the precipitate collects together at or near the bottom of the flasks when the agar may be reheated and refiltered; this time, with the confident expectation that the filtrate will be and will subsequently remain transparent. Or, if preferred, the agar may be run off into cylindrical deposit glasses, sterilized therein, and allowed to stand in the sterilizer, as before, until the sediment has settled to the bottom after which the clear fluid may be syphoned off, or allowed to cool and cut off with a knife and the portion containing the sediment be discarded, or filtered, according to amount.

Usually, on account of the liability to secondary precipitates, and because the agar is never so transparent when filtered immediately as it is when the filtration is deferred until after the first sterilization, I do not filter at once, but merely strain out the coarser flocculi by running the medium through losely packed cotton, sterilize in flasks, allow the flasks to stand in the sterilizer and slowly cool, and wait until the following day before filtering through paper. Filtration is then still more rapid, if care is taken to bring the temperature of the mass up to the boiling point in the sterilizer before commencing the filtration, and the product is always transparent.

The coarser precipitates which occur on sterilization are usually due to the coagulation of albumin which has escaped coagulation at the time of the preparation of the medium; but the troublesome ones are of more doubtful origin; probably they consist, in the first place, of very fine flocculi which pass through the filter on the first filtration, and, in the second place, of salts which are held in solution during the first filtration but which as a result of changes in the reaction, oxidation, or because of lessened solubility in the cold medium and their presence to supersaturation, are deposited as the medium cools.

Digitized by Google

But whatever their nature and cause I have been unable to avoid their appearance altogether save by the method just detailed. When present in only small amount and sterilization is not too much prolonged, (ten minutes) if the tubes are *quickly* cooled they cause no perceptible sediment and only a slight opalescence in the finished product and are then really not objectionable, though I always prefer to have my media perfectly transparent, if possible.

Eggs are not needed to clear the agar when made by the above process, the albumin in the meat juice being sufficient for the purpose.

If it be desirable to make agar from bouillon it is only necessary to rub up the powdered agar with a little of the cold bouillon to a paste and then gradually add the balance of 500 cc. thereof, and boil until solution—which quickly takes place—is complete; add the balance (500 cc.) of the bouillon; stir in the whites of two eggs and boil until the egg albumin is coagulated and rises to the surface leaving the clear solution beneath, and then filter, as before. As, however, the agar can be made from the flesh-water almost as readily and quickly as the bouillon itself, there is little inducement for the use of previously prepared bouillon.

Meat extract can also be substituted for the flesh-water. Formerly I used from 20 to 30 cc. of Valentine's meat juice per liter, but more recently I use but 10 to 15 cc. which quantity I find sufficient. I prefer Valentine's to other extracts that I have tried as it makes a lighter colored agar and seems to be free from resistant spores, as no more care is required in the sterilization of the media made from it than from meat itself. If 10 cc. of meat extract (or meat juice as Valentine terms it), be added to 500 cc. of water and substituted for the flesh-water the process is the same as with the latter, save that egg albumin must be added to clear the medium if it be desired to filter before sterilization. Meat extract, being readily kept on hand, is more convenient than meat for the preparation of media, but some organisms do not seem to thrive so well upon the media thus made.

Digitized by Google

The precaution of first moistening the agar and peptone with a small quantity of cold water or cold bouillon, as the case may be, and rubbing to a smooth paste free from lumps, must not be omitted. If stirred directly into a hot solution—and to a less extent if stirred directly into a large quantity of cold water, without previous moistening—the agar rolls up into little lumps and is almost as difficult of solution as the finely cut pieces of shred agar.

If a meat press is not at hand the flesh-water can be made in the ordinary way either by macerating finely minced meat in cold water for a few hours, or by digesting for a shorter time at a higher temperature.

Digitized by Google

Digitized by Google

CONTRIBUTIONS TO THE HISTOGENESIS OF THE CARYOPHYLLALES. I.

FREDERIC E. CLEMENTS.

The purpose of the following paper is three-fold: 1, to set forth the results of a series of investigations upon the origin and structure of meristematic tissues, and their primary derivatives; 2, to accumulate additional evidence concerning the different phases of present histological, and histogenetic problems; 3, to furnish some considerations for the evaluation of anatomical characters in taxonomy. For many reasons, the order Caryophyllales presents a peculiarly favorable field for these researches. Its comparatively low position among Dicotyledones leads to the expectation that here will be found, to a certain extent, the instability of specializations and differentiations characteristic of low grades of development. The great diversity of morphological characters, moreover, would seem to bespeak concomitant extremes in histogenetic differentiations. Finally, on the other hand, the considerable community of habit throughout the group would tend to produce results quite opposite to those effected by the first two causes. Thus, as is always the case, the resultant of these and other forces would be expressed by the degree of departure of cell-aggregates, and of tissue-systems from a theoretical type. The theoretical reality, but practical non-existence, of this type will be made evident in the course of exposition.

To obviate the necessity of frequent repetition of subject matter, it has seemed best to subdivide the text into three parts. The anatomical and histogenetic details, except such as are common to all Dicotyledones, will be brought out in connection with one of the parts. Thus, while each part will concern itself chiefly with the elucidation of some particular problem in

Digitized by Google

histogeny, there will be found woven in with this the minute anatomy of the organs under discussion. The three subdivisions are as follows:

I. The transition from root to stem.
II. The origin and development of radicels.
III. The apical growth of the stem.

I. THE TRANSITION FROM ROOT TO STEM.

Since the present paper lays no claim to originality in the general facts presented, but only in the particular application of these facts, it has seemed best to give a brief résumé of the principal researches as yet published upon this question. This historical account will be followed by an exposition of the type-structure of the hypocotyl; following this will be found the details of structure, and of transition in the various families of Caryophyllales. After a comparison of the different types of transition, will be given the conclusions deduced from the data presented.

HISTORICAL.

In the beginnings of plant anatomy, the transition-region was regarded as a geometrical plane, and its supposed position was determined by external data. Lamarck, Saint-Pierre, De Candolle, and Saint-Hilaire looked upon it as a line determined on the one hand by what is now called positive geotropism, on the other by negative. De Candolle, in particular, considered the transition-region to be not an actual organ, but merely the limit between two organs. However, he avoided two mistakes into which his successors fell. He located the transition below the cotyledons, and stated that rarely, if ever, was there any external evidence of its position. Saint-Hilaire and Meyen adopted the views of De Candolle, though the former fell into the error of regarding the constriction in the hypocotyl of some plants as an external indication of the location of the transition-region. Gaertner, Richard, Mirbel, aud others thought the transition-region identical with the insertion of the cotyledons, while Cauvet believed it to be equivalent to the radicel.

Digitized by Google

Clos was the first to advance the theory that the "collet" was not a plane limiting two organs, that it was a distinct region determinable by morphological and histological characteristics. Confining himself mostly to the former, he defined the "collet" as that portton of the hypocotyl, limited above by the cotyledons and below by the area of root-hairs. That these alone are insufficient to accurately delimit the "collet" has since been shown by Van Tieghem, and by Gerard. Still, to Clos belongs the credit of having first discovered the real nature and extent of transition. Moreover, although Clos has left us no exact data concerning histological changes in the transition-region, he recognized the presence and importance of such, as the following passage will show. "Although Hugo von Mohl has proved that the vessels of the stem traverse the 'collet', as De Candolle understands it, without undergoing interruption, it is none the less true that it is in the 'collet' (as we have defined it) that the pith begins. It is in the 'collet', moreover, that the fibrovascular bundles, descending from the stem, unite in diverse manners, and undergo modifications, which determine for the root this or that rhizotaxic type. Also, the 'collet', in as much as it is an intermediary organ, partakes sometimes more of the anatomy of the root, sometimes more of that of the first internode of the stem, and and sometimes, finally, it has anatomical characters entirely peculiar to itself".

Van Tieghem, in 1869, first considered the "collet" to be a geometric plane, not entirely dissimilar to a node. His investigations, however, were correct; the cause of error was generalization from an insufficient number of data. As a result of careful anatomical research, he was able to add greatly to Clos' results by defining the "collet" as the organ, "where takes place the passage of xylem strands from alternation to simultaneous semi-rotation and superposition, by which they become centrifugal instead of centripetal, and where occurs the cessation of special conjunctive tissue, which is replaced by primary parenchyma". In 1872, Van Tieghem reversed his opinion concerning the abrupt transition from root to stem, giving for

Digitized by Google

the first time the precise details of the process. According to these later investigations, he divides the transition into four stages: 1, rotation of the xylem strands, which become centrifugal instead of centripetal; 2, their superposition upon the phloem strands; 3, the abrupt interruption of the pericycle without the latter; 4, the dilatation of the central cylinder, with the interposition of the conjunctive tissues. As Gerard has since demonstrated, and as will be brought out in the present paper, the sequence of these stages is not necessarily correct, the fourth as a matter of fact most often preceding the first. Yet these four steps are essentially typical for all Dicotyledones, and it is chiefly in the matter of minute detail that the knowledge upon this subject has since been increased.

Dodel, in the same year, as a result of investigation of the transition-region in Phaseolus, communicated the discovery of two new facts, both of great importance, and of universal application. The first of these was the division of the primary strands during the transition, and the second, the assumption of an intermediate, tangential (secantial) position, as a result of the torsion of the radial bundles to become collateral. In 1876, Goldsmith confirmed Van Tieghem's results, extending them, however, so that the "collet," which all recent writers had understood as limited to the hypocotyl, was, in a considerable number of cases, found to be located above the cotyledons. Another important deduction reached by the same author was that there is no interrelation between the morphological characters of the seedling, and the histological characters of the transition-region.

Gerard, in 1880 and 1881, extended his investigations so as to include all groups of vascular plants: it is his researches that have laid the foundation for all future work upon the "collet." Not only did he corroborate and extend the essential facts as demonstrated by Van Tieghem, Dodel, and Goldsmith, but he accumulated a mass of details that must stand as classic upon this question. His conclusions are a succinct résumé, not merely of his own investigations, but of the antecedent researches, and warrant a full translation in this place.

Digitized by Google

"To summarize: the 'collet' as a geometric plane does not exist.

"There exists, between the stem and the root, a region, more or less extensive, according to the plant, in which the elements of the root, in ascending to the higher portions of the axis, are modified, displaced, and assume gradually the configuration, position, and importance which they possess in the stem.

"The transformation of each of these elements is independent of the modifications of the adjacent elements; it may be continuous, or it may take place at intervals more or less separate; sometimes slow, it is at other times extremely rapid. The transition may originate, indifferently, in one or the other element: the one which inaugurates the transition here, will be the last to be adapted to it there. It results from these facts: 1, that the 'collet,' anatomically speaking, viewed in its different aspects, and in several plants at one time, presents the most various expressions, incalculable in number; 2, that the transformation of the tegumentary system is unable to furnish any character for the delimitation of stem and root. The mutation of the epiderm is but one of the phases of the transition; it occurs at very diverse times.

"Taken in its largest dimensions, the 'collet' may originate in the superior portion of the radicle, and may terminate in the fourth internode, though it rarely exceeds the cotyledons. It can be entirely localized in the radicle; it may occupy a portion of this organ, and all, or part, of the caulicle; finally, concerning the caulicle alone, it may comprise the totality, or only a part of it. It is seen, then, with what caution one should employ the two terms, radicle and caulicle; convenient, it is true, in descriptive writing, but liable to give rise to false ideas concerning the structure of these two organs.

"Most frequently, the transition occurs gradually, and completely in the hypocotyledonary axis; but, when the elements of the root reach the cotyledons, and are entirely lost in them without having realized the caulinary type, there is an abrupt change at the base of the internode, since the epicotyledonary

Digitized by Google

axis always possesses the elements of the stem normally disposed.

"The extent of the 'collet' seems everywhere dependent upon the diameter of the plantlet. The greater this is, the more quickly the transition takes place; but it is necessary to add, that, beyond a minimum dimension, this cause seems to have no influence. The absence of the caulicle affects also the rapidity of the movements, and, consequently, the length of the 'collet.' This region is extremely short with the vascular cryptogams, and the monocotyledons deprived of this organ. An extensive pith in the root, facilitating the displacement of the elements, also renders the transition more rapid.

"There is no family character to be drawn from the study of the 'collet.' There is merely a certain constancy in the species; whatever the longitudinal development of the plantlet, the elements possess the same disposition beneath the cotyledons."

Gerard's conclusions, well-founded and complete as they are, leave three very evident lacunæ: 1, concerning the constancy of transition-type and method for each species; 2, the reduction of the manifold forms of transition to a definite number of more or less well-defined types; 3, a determination of the concomitancy of transition types, and accepted diagnostic characters in the higher groups. It would be presumptuous in a paper so limited in scope as the present one to postulate final conclusions with reference to any of these questions. The Caryophyllales afford, however, much cumulative evidence, the import and weight of which will be hereinafter discussed.

GENERAL FACTS OF THE TRANSITION.

The tegumentary cylinder plays no part in the transition. The epidermis of the root, however, which is characterized by the possession of root-hairs, and by its rounded, irregular, loosely-disposed cells, undergoes very considerable modifications. It first loses its root-hairs; the cells increase in size transversely and their outer walls begin to cuticularise. Finally, they are reduced in number about one-half, they elongate radi-

Digitized by Google

ally, and become very firmly compacted together, so that outwardly they present a continuous, cuticularised surface. The exoderm undergoes at the same time corresponding changes. It gradually loses its property of suberisation, the cells decrease considerably in size; and ultimately become more or less collenchymatous.

The transformation of the epiderm, although a feature of the transition, is in no way, or at least indirectly alone, connected with the changes which occur in the central cylinder. In most cases, the transformation of the epiderm takes place completely, before the first step of the internal transition has occurred. In some instances, on the other hand, the internal transition is practically accomplished before the epiderm loses those features which characterize it in the root. Thus, it is readily seen that the epiderm and the central cylinder are practically independent of each other with respect to their behavior. As for the transformation itself, it may take place rapidly, or gradually; it may extend over a large, or a small portion of the hypocotyl.

The cortical cylinder is modified but little. The number of layers of cells ordinarily increases toward the cotyledons, and at the same time the size of the cells undergoes a consequent decrease. Their form frequently changes from polyedric to rounded, and the whole tissue becomes characterized more and more by intercellular spaces. The endoderm, also, suffers but slight changes. It loses its property of suberisation, the characteristic punctation disappears, and it becomes, toward the apex of the seedling, more and more amyliferous.

The modifications which affect the pericycle are inconsiderable. In many plants, the pericycle persists from the tip of the root to the cotyledons without the slightest variation except in the number of cells. Even when it enters the cotyledons, which it does in company with the endoderm, and the entire cortical cylinder, it suffers no change. In some cases, however, there is a diminution in the size of the pericyclar cells situated in front of the phloem strands, and, not infrequently, some, or all the cells directly opposite the phloem disappear.

Digitized by Google

Although Gerard makes the distinct statement that the mesenchym is entirely passive, the evidences of its activity are so numerous as to make it impossible to accept such a conclusion. Its function is four-fold: 1, to bring about the separation of the xylem strand into two plates, and, sometimes, the subsequent disintegration of these; 2, to intervene between the prototracheids and the pericycle; 3, to give origin to the medulla of the central cylinder; 4, to originate the procambium.

While the mesenchym may be regarded as the causative tissue, it is the xylem that is chiefly concerned in the changes which occur in the central cylinder. The process by which the centripetal xylem of the root is transformed into the centrifugal xylem of the stem may be divided into five stages:

1. Duplication and equalization of the xylem elements.
2. Longitudinal segmentation of the xylem strand into two plates.
3. Approach of xylem and phloem.
4. Superposition of xylem upon the phloem in secantial orientation.
5. Mutation from secantial to collateral orientation.

The first stage takes place by the transformation of the adjacent cells of the mesenchym into tracheids, and the decrease in diameter of all the elements of the xylem. In the second, the cells of the mesenchym insinuate themselves between the central xylem elements, and, growing rapidly, force them apart into two plates. At the same time, the prototracheids are pushed back from the pericycle by the mesenchym, and they take part in the constitution of either plate. In the third stage the xylem plate, either as a whole, or in part, approaches the phloem, or in some cases, the movement appears to be mutual. In the fourth, the xylem is superimposed upon the cambium in face of the phloem. From linear, or plate-like, it becomes cuneiform, and passes quickly from the secantial orientation to the collateral, the fifth stage. In elongated, slender hypocotyls, the fifth stage is rarely reached below the cotyledons, and sometimes it is found just above them. In short, stout hypocotyls, it is usually found in the lower portion of the "tigelle",

Digitized by Google

the upper part of which then exhibits the structure of the stem proper.

Compared with that of the xylem, the behavior of the phloem is very simple. At the beginning of the transition, the phloem strands extend themselves along the pericycle. When the xylem splits, the phloem frequently divides also; sometimes, however, it remains entire, and division occurs only after the superposition of the xylem. In the assumption of the secantial orientation, the phloem is usually passive, though movement does sometimes take place in it, as well as in the xylem.

The cambium (procambium) is produced directly from the mesenchym. Its purpose is two-fold; to connect the xylem and phloem into the collateral bundle, and to originate, in most cases, the vascular strands of the first internode.

DETAILS OF STRUCTURE AND TRANSITION IN THE VARIOUS FAMILIES.

CARYOPHYLLACEÆ.

Dianthus sinensis. The tegumentary cylinder of the root occupies more than three-fourths of the diameter. It consists, besides the epiderm, exoderm, and endoderm, of a cortical parenchyma of three or four layers of rounded cells, with numerous very small intercellular spaces. The outer layer is usually the largest, and from it the adjacent layers gradually decrease in size, on the one hand toward the epiderm, on the other toward the endoderm. In some cases, contrary to Van Tieghem's and to Gerard's generalizations, the cells of the exoderm are the largest of the tegumentary cylinder. There is, then, an abrupt change to the numerous small cells of the epiderm, and a gradual transition towards the cells of the endoderm. The cells of the latter are prismatic; their walls are so closely applied to those of the pericyclar cells that intercellular spaces are nearly invisible, or utterly lacking (I:1).

The central cylinder possesses a simple, one-layered pericycle, composed of 25 to 30 polyedral cells. The stele is diarch, each xylem strand containing, ordinarily, four, rarely five or six, elements, the outermost of which, prototracheid, lies against

Digitized by Google

the pericycle. The two strands are united in the centre by a large tracheid, and the double xylem strand is thus a single row of elements for, at least, a large portion of the root proper. The number of rows in the rays of the mesenchym is regularly three. Where the mesenchym touches the pericycle, its cells alternate with the cells of the latter, and it is only to be distinguished from a second layer of the pericycle by the fact of its interruption by both prototracheids and protophloem. The two phloem strands consist of plate-like masses, extending the length of four or five pericyclar cells. They contain two sorts of elements, large primary sieve-tubes, alternating with the cells of the pericycle, and small, cuboidal or polygonal cells, scarcely separable from the mesenchym.

The first change in the structure of the root takes place in the epiderm and the exoderm. The manner and nature of this has already been pointed out. Its complete independence of any transformation in the central cylinder is evidenced by the fact that both epiderm and exoderm have practically assumed their ultimate expression, before there has been the least disturbance of the elements in the central cylinder (I:7,8).

At a distance of about three millimetres from the tip of the root, the cells of the mesenchym adjacent the large, central tracheid become lignified, and pass over into constituents of the xylem strand. At the same time, there is a considerable increase in the size and activity of the phloem strands. They may now become more or less broken up into two separate strands (I:2) or they may maintain their integrity for some time yet. About a millimetre above the increase of the xylem strands, the mesenchym grows in between the elements of the latter and forces them apart first into two more or less irregular plates (I:3), and finally, by continued intrusion, into a number of very irregular, isolated strands. Just previous to this, the mesenchym in face of the phloem strands has passed over into cambium, and the phloem itself, if still undivided, splits into a number of strands, which come to lie along the pericycle for a very considerable distance, ultimately being distributed here and there along almost the entire periphery (I:4).

Digitized by Google

The prototracheids, during these changes, assume a position more remote from the pericycle, and, with the adjacent xylem, form the xylem element of the bundle-trace of the cotyledons (I:5). These enter the cotyledons, with respect to the phloem strands which accompany them, in secantial orientation, which, however, passes over almost immediately into the centrifugal. In some cases the whole number of the xylem strands is carried into the cotyledons, and the fibrovascular strands of the first internode, the stem proper, arise from the residual phloem-cambium of the hypocotyl (I:6). In other instances, the fibrovascular strands, alternating with those destined for the cotyledons (I:5), enter the first internode, and, by division, give rise to the vascular system of the stem.

The transition-region extends, then, from the upper portion of the root proper to the cotyledons, and includes the whole of the hypocotyl above the collet, the "tigelle".

Silene armeria. The diameter of the tegumentary cylinder of the root is very variable. Near the tip, it consists of but four layers, epiderm, exoderm, one-layered cortical parenchyma, and endoderm. The transition in size takes place only toward the central cylinder, the exoderm alone equalling the cortical parenchyma and the endoderm in extent. In the vicinity of the collet the number of rows in the parenchyma increases to two or three, and the outer of these dominates the cylinder, so that decrease, as normally, takes place in two opposite directions, toward both epiderm and exoderm. The cells are now nearly orbicular, and the tissue of the entire cylinder is characterized by very numerous and regular intercellular spaces, which are entirely lacking in the root. The cells of the endoderm are more or less elongated transversely, so that, ultimately, they become prismatic.

The pericycle is simple and contains 25 to 30 polyedric cells. As in *Dianthus sinensis*, it persists up to the cotyledons, increasing the number of its cells to correspond to the expansion of the central cylinder: in face of the phloem strands, the pericyclar cells sometimes diminish in size, but apparently never wholly disappear. The composition and arrangement of xylem

Digitized by Google

and phloem are very similar to that already indicated for *Dianthus sinensis*. The xylem is diarch, and consists usually of nine elements, four in either arch, connected by a large, central one. The behavior of the xylem is quite different in different individuals. Ordinarily, the single-rowed strand persists until the region of transitional activity in the upper part of the root is reached. Frequently, however, at a very short distance from the tip, the xylem becomes two- or three-rowed, and the root maintains this structure until the collet is reached. The phloem, composed of both primary sieve-tubes and smaller accessory vessels, forms a columnar strand on either side the xylem, and separated from it by two rows of mesenchymatous cells.

The transformatiun of the epiderm and the exoderm takes place in the region of the collet, and is effected in a very short distance, being completed before modification of the central cylinder occurs.

As has already been pointed out, the xylem strand is frequently doubled in the lower portion of the root. When this is not the case, duplication occurs in the collet (II:1). In either instance, the real index of the beginning of the transition is to be found in the equalization of the diameter of the xylem elements, and the withdrawal of the prototracheids from the pericyle. Concomitantly, the mesenchym begins to grow vigorously, and those layers in front of the phloem strands pass over into the peculiarly cubical cells of the procambium. These changes take place less than a millimetre from the insertion of the cotyledons. The actively growing mesenchym pushes in between the xylem elements, and separates them first into two irregular plates (II:2). The phloem undergoes no important change, but simply extends itself further along the pericycle: the entire mesenchym, except that concerned in the disintegration of the xylem, and destined to become the pith, is transformed into procambium. The medulla soon appears in the center of the cylinder, and the xylem strands are separated into numerous secondary strands. The secondary xylem strands come to lie in four more or less definite, oppositive groups

Digitized by Google

(II:3). The phloem apparently does not split into corresponding groups, but is, on the contrary, differentiated out of the procambium along the entire periphery. This condition, which is essentially that of secantial orientation, is attained a short distance below the cotyledons. By the time the latter are reached, the fibrovascular system is practically centrifugal. This is actually true, however, only for those strands destined for the first internode. Those which form the trace of the cotyledons are still slightly secantial, until the very moment of their entrance into the latter. The base of the first internode possesses a stele composed for the most part of procambium, but containing, also, the two vascular bundles received from the hypocotyl.

The transition-region, if the duplication of the xylem elements in the lower portion of the root may be excepted, begins scarcely more than a millimetre below the cotyledons, and terminates at the insertion of the latter.

Silene conoidea. The transition-region corresponds in the details of structure, location and extent so exactly to that of *Silene armeria*, that an exposition of it would be the merest repetition. The two species might well be one in so far as histological differences are concerned.

Silene otites. The transition region, though agreeing in the main with that of *Silene armeria* and *conoidea*, presents a few differences, which, though unimportant, are more or less constant. Among these is the very early appearance and abundant distribution of starch-granules in the endoderm (IV:3), a condition which takes place tardily and feebly in the other two species. The disintegration of the xylem strand occurs somewhat later also, and, in consequence, the stele has scarcely more than entered the secantial orientation by the time it reaches the insertion of the cotyledons (IV:4). The centrifugal arrangement of xylem and phloem takes place, then, at the very moment of entrance into the cotyledons, as was seen sometimes to be true in *Silene armeria*. The strands of the first internode have at this time, though little differentiated, already assumed collateral orientation.

Digitized by Google

According to Gerard's expositlon, the details of transition in *Silene inflata* are in almost perfect accord with the facts already stated. The sole discrepancy is in the behavior of the phloem. In *Silene inflata*, it divides before passing into secantial orientation with the xylem; in *Silene armeria*, *conoidea* and *otites*, division of the phlœm strands apparently never occurs. On the contrary, the procambium gives rise to accessory phloem, which forms, with the original strands, a more or less continuous circle within the pericycle.

In *Lychnis githago*, Gerard found the facts to be practically the same, with the exception of an additional step, consisting in temporary fusion of the strands during secantial disposition.

In the six species of Caryophyllaceæ investigated, the transition-region is based upon a single type of structure, the modifications of which are slight and of little importance. The transition-region, moreover, is always limited below by the collet; and above by the cotytedons, and, in most cases, is confined to the upper portion of the "tigelle" alone.

Portulacaceæ.

Portulaca oleracea. The tegumentary cylinder of the root occupies about three-fourths of its diameter. Besides the epiderm, exoderm and endoderm, it consists of a one-rowed cortical parenchyma, a condition which persists even to the cotyledons. The exoderm is uniformly composed of larger cells, and transition in size is, in consequence, regularly unilateral, i. e., towards the endoderm. The tissue of the cylinder is very compact, the cells are for the most part polygonal, and the intercellular spaces none. The cells of the endoderm differ considerably from those of the other layers in their elongated, prismatic form, as seen in transection.

The pericycle is one-layered, and contains usually about 25 cells. The cells in face of the phloem strands decrease greatly in size, especially upwards in the stem, and, before the cotyledons are reached, they disappear entirely. The stele is diarch, each xylem ray consisting usually of three elements, united in the centre by means of one large vessel. The prototracheids

Digitized by Google

lie directly against the pericycle. The phloem strands are more or less convex; and consist, in the lower portion of the root, of but six or eight elements, slightly differentiatcd from the mesenchym. The latter is composed regularly of two rows of cells.

The modification of epiderm and exoderm occurs at the very base of the "tigelle," while the structure of the stele is yet typical. It is rapid and is completed in a rather short distance.

As usual, the first indications of the transition are to be fonnd in the conversion of adjacent cells of the mesenchym into xylem elements (V:1). The duplication of the xylem is never carried far, resulting almost always merely in the formation of a double-rowed xyiem strand. At the same time equalization of the size of the elements occurs, and concomitant with this, the division of each phloem strand into two, resulting in the formation of four secondary strands, which assume a quadrate position (V:2). The cells of the mesenchym now penetrate the xylem strand, separating the metatracheids from the prototracheids, but leaving the xylem grouped generally into two plates (V:3). Simultaneously, the interposition of mesenchym between pericycle, and prototracheids takes place. The pith grows rapidly in the centre of the cylinder, and either xylem plate is forced back upon the two secondary phloem strands, which have grown toward each other, and have united (V:4). The interposed mesenchym is meanwhile converted into procambium. Alternating with the two bundles thus formed, are two large strands of procambium, arising from the modification of the mesenchym. Thus, the whole of the xylem and phloem elements of the hypocotyl is concerned in the fibrovascular strand of the cotyledons (V:5). Just below the cotyledons, each of the procambial strands divides into three parts, each of which is differentiated into a fibrovascular bundle, and as such enters the first internode. The orientation of vascular strands is, thus, typically collateral just below the insertion of the cotyledons, and the transition-region is bounded above by the latter.

Portulaca oleracea differs from all Caryophyllaceæ (except

Digitized by Google

sometimes *Dianthus sinensis*) investigated, in the constitution of the fibrovascular bundles of the cotyledons by the entire vascular portion of the stele; from all but *Silene inflata* (rarely *Dianthus sinensis*), in the division of the phloem strands.

NYCTAGINACEÆ.

Allionia hirsuta. The tegumentary cylinder is especially broad, the number of layers in the cortical parenchyma is ordinarily five or six. The cells of the layer next within the exoderm are the larger; from these inward, the decrease in size toward the small endodermal cells is very gradual, toward the epiderm, it is abrupt. The cells of the tissue are globose, and the tissue itself is characterized by numerous, small intercellular spaces. The cells of the endoderm are almost perfectly globose in shape, and early undergo cuticularisation.

The pericycle is simple and consists of about 40 cells. These persist without noticeable modification throughout the root. The stele is diarch, rarely pseudo-tetrarch. In its simplest expression, it is but a single row of vessels, of which there are five in each arch, a large central one serving to unite the two archs. This condition is found for the most part only near the tips of roots. In most cases the xylem strand is two-rowed (VI:1). The centre of the cylinder is occupied by a very large tracheid, about which is grouped a circle of similar, smaller elements, which are continued bilaterally into an arch consisting of six or seven tracheids. Such a strand is, of course, nothing but an anticipation of duplication: its constancy lends especial significance to it, however. The prototracheids do not touch the pericycle, but lie against certain cells, which seem to indicate a double-layered pericycle at these two points. The mesenchymatous rays are very broad; they consist of seven or eight rows of regular, polygonal cells. The phloem strands comprise three rows of cells; the inner cells are small and scarcely distinct from the mesenchym, the outer are large and globose. They lie, for the most part, directly against the pericycle and constitute the primary sieve-tubes.

Contrary to what has been noted heretofore, the mutation of

Digitized by Google

the epiderm does not precede the disturbance of the elements in the stele, but is subsequent to it. In fact, the peculiar, non-cuticularized epiderm has undergone little modification by the time the transition from root to stem is really completed.

From what has been said above, it follows that duplication and subsequent equalization of the xylem elements is not the first indication, nor necessarily an indication at all, of the beginning of transition. The thickening of the walls of the central xylem elements disappears, "runs out", and simultaneously appears the intrusion of the mesenchym. The central elements are burst apart, and the xylem separates into two plates, for the most part transversely, but also somewhat obliquely (VI:2). By the further growth of the mesenchym, these plates are separated into four xylem strands (VI:3), of which the prototracheidal ones, though destined to disappear, serve to mark the trace of the primary bundles descending from the first internode. The other two strands, forced further and further back by the growing medulla, come to lie near the phloem plates, each of which has begun to divide (VI:3). Each of these two xylem plates now divides to form three, the middle one of which is like the prototracheids, marked for disappearance, while each outer one assumes a position near its corresponding, secondary phloem strand (VI:4). At the same time, the mesenchym in front of the phloem is transformed into cambium, the tracheids pass from the secantial disposition to a point directly in face of the cambium, and the bundles become collateral (VI:5).

The entire transition has taken place in that region of the hypocotyl, the collet, where occurs the abrupt change in the diameter of the seedling. The whole of the "tigelle," then, possesses the structure of the stem proper. It is characterized by four collateral bundles, which a short distance below the cotyledons are increased to six, by the appearance of the two primary bundles of the first internode, which arise directly above the disappearing prototracheids (VI:6). Imbedded in the pith at either end, still persist some of the tracheids of the vanishing middle strand of the xylem mentioned above.

Digitized by Google

Allionia nyctaginea. The structure of the root, and the structure, location and extent of the transition-region present no appreciable difference from the structure of the same organs in *Allionia hirsuta.* The points of correspondence are practically perfect for every stage.

According to Gerard, the transition region of *Mirabilis jalapa* corresponds in every detail with the statements made above for *Allionia hirsuta*, and *nyctaginea.* He considers, however, that the total disappearance of the residual tracheids marks the termination of the transition-region. This conclusion seems to be entirely unwarranted; the persistence of the unused tracheids is more or less accidental, and has no particular significance. If Gerard's view were to be regarded as correct, the term transition-region, would be applied to a portion of the hypocotyl, the upper three-fourths of which is characterized by perfectly collateral bundles; manifestly a misapplication.

The transition-region of the Nyctaginaceæ, compared with that of the Caryophyllaceæ, occupies but a small extent of the hypocotyl. It is located uniformly in or near the collet, and often is almost entirely confined to it. The transition may be regarded as belonging to another type, characterized by the fact that the prototracheids, or their trace, enter the first internode, and not the cotyledons, as is the case in Caryophyllaceæ and in Portulacaceæ.

Amarantaceæ.

Amarantus retroflexus. The cortical parenchyma of the root comprises two or three rows of which the outer, as usual, is the larger. The exoderm differs but slightly from the outer layer, and, in fact, the two are often confluent. The tissue of the tegumentary cylinder is composed of globose cells, between which there are numerous, irregular intercellular spaces. The cells of the endoderm are very similar.

The pericycle is simple and contains usually about 20 polygonal cells. Those in face of the phloem undergo a very considerable diminution in size, while, in the upper part of the

Digitized by Google

hypocotyl, they disappear entirely. The xylem strand is diarch; each arch is composed of three or four elements, the outermost of which lies against the pericycle. The mesenchym is three-rowed and passes insensibly into the phloem strands. The latter are more or less cuneiform, and are composed of about twelve elements.

The transformation of the epiderm takes place, as is usual for slender hypocotyls, before the beginning of the transition. In the present case, the complete modification of the epiderm results long before the first change occurs in the central cylinder.

The transition is inaugurated by the duplication of the xylem elements and their subsequent equalization (VIII:2). The thickening of the walls of the mesenchymatous cells is only partial, however, and the next stage follows so quickly that, when the mesenchym appears in the centre of the cylinder, it ordinarily divides a single-rowed xylem transversely into two plates (VIII:3). Simultaneously, the prototracheids leave the pericycle, and each phloem strand undergoes division (VIII:3). Following this, a strand of procambium is developed from the mesenchym on either side in the space left by the separation of the secondary phloem strands. Each xylem arch is now further split up by the mesenchym, several elements assume a position in front of either phloem strand, the cambium appears, and the vascular strands take up the secantial orientation (VIII:4). During this process, the pith has made its appearance in the centre of the cylinder. Meanwhile, also, the procambial strands have developed into perfectly collateral strands destined for the first internode. Just below the cotyledons, the xylem of the strands in secantial orientation turns upon the phloem, and seeks to take up a centrifugal position (VIII:5). This step, however, is rarely accomplished before the strands enter the cotyledons, where they assume the typical collateral disposition.

In some hypocotyls, the strands reach the cotyledons even before they have taken up the secantial disposition. In such instances, the phloem and xylem, both still centripetal, enter the

Digitized by Google

cotyledons, and are there properly oriented. The mesenchym, then, early develops the lateral, procambial strands, and these enter undifferentiated, the first internode, where they are quickly converted into primary vascular bundles. In such individuals, there is always an abrupt transition from "tigelle" to stem at the insertion of the cotyledons.

Whether the transition be gradual, as is normally the case, or abrupt, as just described, the whole of the xylem, and generally the entire phloem, passes into the cotyledons. The trace of the first internode is formed, then, by the conversion of the interfascicular mesenchym into procambial strands. More infrequently, each phloem strand, instead of dividing into two secondary strands, splits into three, and the middle one of these is differentiated into a vascular strand of the first internode. The six vascular strands of the second internode are formed by the splitting of each of the primary strands of the first internode into four, three of which enter each cotyledon, while the fourth passes into the third internode.

As has been found elsewhere to be the case in species of the same genus, *Amarantus albus* presents no material points of difference in the details of the structure of the seedling.

The manner of transition in *Amarantus paniculatus*, according to Gerard, is in perfect accord with the second method described for *Amarantus retroflexus*. In consequence, *Amarantus retroflexus*, *albus*, and *paniculatus* are characterized by exactly the same type of transition-region, notwithstanding the fact that this type shows slight modifications in different individuals.

The transition-region in Amarantaceæ begins, then, in the upper portion of the "tigelle", a considerable distance above the transformation of the epiderm, and is terminated by the cotyledons.

CHENOPODIACEÆ.

Beta alba. The tegumentary cylinder occupies four-fifths of the diameter of the root. Besides the epiderm, exoderm, and endoderm, it possesses a cortical parenchyma, composed

Digitized by Google

of five or six rows of cells. The middle row is the largest, and the diminution of successive layers toward both epiderm and endoderm is gradual. The cells are irregularly polygonal, and the tissue abounds in regularly rounded intercellular spaces. The endoderm is composed of compact, cuboidal cells.

The pericycle is simple and comprises usually about 40 cells. The pericyclar cells, though diminishing in size above in face of the phloem strands, persist until they reach the cotyledons, which they enter along with the cortical cylinder. The xylem is diarch, each arch consisting of four or five elements, of which the prototracheids, indifferently, lie against the pericycle or remote from it. The mesenchym is broad and contains four or five rows of regularly polygonal cells. The phloem strands are large plates, extending for a considerable distance along the pericycle. They are four- or five-rowed, and comprise two sorts of elements. The inner rows consist of small cells scarcely separable from the mesenchym, the outer row is composed of large, primary sieve-tubes, which lie against the pericycle.

The transformation of the epiderm occurs in the upper part of the root, only a short distance below the duplication of the xylem elements.

The increase in number of elements in the xylem, and the equalization of their diameter takes place in the middle of the collet (IX:2). Concomitant with this, the layers of mesenchym adjacent to the pholem pass over into procambium. The mesenchym then forces itself in between the xylem elements, and the metatracheids are separated from the original strand (IX:3). By the further intrusion of mesenchym, the xylem is split into two secondary strands, which are pushed back toward the periphery. At the same time, each phloem strand divides, and the two resulting parts become somewhat widely separated (IX:4). The stele reaches the cotyledons in this condition, and the xylem and phloem strands pass directly into the seed-leaves, where they assume their proper disposition. More rarely, the phloem strands on either side the xylem become con-

Digitized by Google

fluent along the pericycle, and the xylem and phloem then enter the cotyledons in secantial orientation. The mesenchym, which grows in between the secondary strands of the phloem, is transformed into procambial strands, which, above the cotyledons, are differentiated into the primary bundles of the first internode. Thus, the whole of the vascular elements of the stele passes into the cotyledons.

Chenopodium album. The cortical parenchyma is ordinarily three-rowed, the outer row is the largest, and the others decrease gradually toward the endoderm. The latter is composed of rounded, close-fitting cells, very much smaller than those of the inner layer of the parenchyma. The pericyle is simple, and is composed of about 20 cells. It persists with but little change, apparently, throughout the hypocotyl. The xylem is diarch, each arch containing three or four elements. The prototracheids lie directly against the pericycle. The mesenchym is two-rowed; it passes gradually into the inner row of the phloem strand. The latter possesses two or three primary sieve-tubes, lying against the pericycle (X:1).

The transformation of the epiderm takes place in the upper part of the root, some distance below the collet, and several millimetres below the beginning of the transition.

The duplication of the xylem begins three or four millimetres, or more, below the cotyledons. At the same time, the separation of the prototracheids from the pericycle takes place (X:2). Some distance above, the mesenchym grows in between the xylem, dividing it into two strands. Concomitantly, the division of the phloem strands, and the subsequent separation of the secondary strands occurs. The ends of the secondary xylem strands approach the secondary phloem strands, and the transition from the secantial to the collateral orientation begins (X:3). In the early steps of this process, the fibrovascular strands for the first internode are cut off and quickly assume the collateral disposition. The passage of the bundles destined for the cotyledons from centripetal to centrifugal is laborious, and requires considerable time. It is accomplished by the gradual approach of the secondary phloem strands, and by

Digitized by Google

the swinging toward each other of the xylem plates upon the prototracheids as a pivot. Just before entering the cotyledons, the two adjacent bundles become confluent, and enter the cotyledons as a simple vascular strand. Simultaneously, the strands passing upward into the internode undergo division in rapid succession, so that the first internode possesses twelve vascular strands, three toward either face. Six of these, the three on either side, which alternate with the cotyledons below, pass into the leaves of the first internode; the remaining six enter the second internode, where they again undergo division.

Contrary to Gerard's conclusions upon the effect of the diameter and length of the hypocotyl upon the rapidity of transition, *Beta alba*, with a short, thick hypocotyl, possesses a truncated transition-region, and the vascular elements of the stele are forced into the cotyledons long before they have assumed the customary arrangement. In *Chenopodium album*, on the contrary, where the hypocotyl is exceedingly slender and elongate, the transition is perfected, and the "tigelle" has the structure of the stem before the insertion of the cotyledons is reached.

Atriplex hastata, investigated by Gerard, is intermediate between the two plants studied above: the vascular elements of the stele pass into the cotyledons while in secantial orientation.

Phytolaccaceæ.

Phytolacca decandra. The tegumentary cylinder occupies nearly two-thirds of the diameter of the root. The cortical parenchyma consists of three or four layers of almost uniform size; toward the endoderm, the cells become slightly smaller. The latter are polygonal, and the tissue is compact, and almost without intercellular spaces. The endoderm is not at all distinctive; it is simply the inner layer of the cortical parenchyma.

The pericycle is simple at first, comprising about 40 cells. In the upper part of the root, however, it undergoes division to form a sort of procambial tissue, and it maintains this condition until it enters the cotyledons. The xylem is diarch: each arch consists of five to eight elements. The prototrach-

Digitized by Google

eids usually lie against the pericyle, but this is not necessarily true. The mesenchymatous rays are broad, and contain five or six rows of cells. The phloem strands are characteristic; they are composed almost wholly of eight to twelve large primary sieve-tubes.

As has already been demonstrated for those plants which experience an abrupt change of diameter in the colletal region, the transformation of the epiderm occurs comparatively late. In *Phytolacca decandra*, the epidermal cells finally acquire the characteristics of the epiderm of the stem a short distance above the collet. This external change corresponds internally with the appearance of the medulla in the central cylinder.

The duplication of the xylem strand occurs in the upper portion of the root, not far below the collet (XI:1). About one millimetre above this point, the mesenchym intrudes itself between the xylem, and the latter is divided transversely into two equal, secondary strands (XI:2). Shortly after, each secondary strand is again split into three, of which the middle one contains the prototracheids (XI:3). Concomitantly, the outer strands approach the phloem, the adjacent mesenchym is modified to form cambium, and the vascular elements of the stele assume the secantial orientation. The strands do not divide, but extend themselves along the pericycle and, together with the procambial strands developed from the mesenchym, form a circle of phloem elements, interrupted only in face of the prototracheids. The secondary xylem strands swing slightly away from each other, and tend to assume a more nearly collateral disposition. They enter the cotyledons, however, before this is accomplished, and the perfectly collateral arrangement is only realized there. The prototracheidal strands furnish the middle bundle of the cotyledons, and the outermost secondary strands, the lateral.

In some individuals, a peculiar modification of this method of transition is presented, which, in many respects, is identical with that demonstrated for *Allionia hirsuta* and *nyctaginea*. The xylem is first split into four alternating strands, two prototracheidal, and two purely secondary. The latter again

Digitized by Google

divide into three, the outermost of which assume a position near the phloem strands, which have already divided. The passage from the secantial to the collateral disposition takes place almost instantaneously. The stele now contains four collateral bundles, and alternating with these, four secondary, reduced xylem strands, and presents exactly the arrangement characteristic of *Allionia hirsuta* (VI:5) and of *Allionia nyctaginea* (VII:5). This disposition is maintained for nearly a millimetre: the two xylem strands, which were the middle ones formed by the splitting of the secondary xylem plates after the separation of the prototracheids, are, however, transformed into collateral bundles before the cotyledons are reached. Before entering the cotyledons they divide and one-half of each goes to either cotyledon, forming the outermost strand. Of the four original collateral bundles of the upper portion of the hypocotyl, two enter either cotyledon and form the principal strands. Central, between these two, still persists the prototracheidal strand, represented only by two or three spiral vessels.

Phytolacca decandra thus presents two widely different modifications of the one type of transition. The one first described appears to be the more frequent, the second, rather exceptional. That they are modifications of one type, and not two distinct types, is shown by the fact that, in both cases, the vascular elements of the central cylinder of the hypocotyl pass, in their entirety, into the cotyledons, while the fibrovascular system of the first internode is derived from the procambial stele, which enters it from below. More commonly, the elements of the hypocotyledonary stele reach the cotyledons before they attain their ultimate expression, and the transition-region is truncated. In rarer instances, and for reasons which are correlates of the individual development of each plant, the transition occurs in the lower portion of the hypocotyl, and, in consequence, the collateral structure of the stem characterizes the greater part of the "tigelle".

Digitized by Google

Gerard's investigations of *Phytolacca decandra* have led him to assign to it a method of transition for the most part in accord with what has been presented above as normal.

Polygonaceæ.

Polygonum lapathifolium. The tegumentary cylinder, in addition to epiderm, exoderm and endoderm, possesses a cortical parenchyma comprising five or six layers. The middle layer, or layers, is uniformly the largest, and the decrease in size of the other layers is very gradual toward both endoderm and epiderm. The cells are typically Maltese-cross-shaped, and the tissue is characterized by the large and regular intercellular spaces. The endoderm, on the contrary, is very compact, and its cells are cuboidal.

The pericycle is simple, and persists with slight modifications until the cotyledons are reached. The xylem is tetrarch. The archs are placed at right angles to each other, and consist usually of four elements, united in the centre by a larger one. The prototracheids lie directly against the pericyclar cells. The phloem strands are likewise four: they are more or less cuneiform, and are separated from the xylem rays by two or three rows of mesenchymatous cells (XII:1).

The transformation of the epiderm occurs in the upper portion of the root, while the typical disposition of the stelar elements is yet undisturbed.

Duplication of the xylem elements, and their subsequent equalization never occurs. The beginning of the transition is indicated by the disintegration of the central xylem element, and the appearance of the mesenchym in the centre of the cylinder. The rays of the xylem strand are separated from each other, and are pushed back toward the pericycle (XII:2). Shortly after, the phloem strands grow rapidly and extend along the pericycle until they reach the xylem. The phloem elements then group themselves about the xylem strands, and are, at the same time, crowded out midway between the xylem bundles by the mesenchym (XII:3). The bundles, or, rather, the masses of phloem and xylem, are still centripetal, and they

Digitized by Google

enter the base of the cotyledons with this disposition. The whole number of xylem and phloem elements pass into the cotyledons. In consequence, the stele of the first internode is formed by the modification of the internal mesenchym of the hypocotyl into procambium.

The transition-region of *Polygonum lapathifolium* commences in the collet, and terminates only in the base of the first internode.

Rumex altissimus. The features of the tegumentary cylinder are essentially similar to those already noted for *Polygonum lapathifolium:* the same is true of the pericycle.

The xylem is tetrarch, but the rays are of different value. Two, the primary, usually contain four elements and the prototracheids lie against the pericycle, while the alternate two, the secondary, comprise but two or three elements, which rarely attain the pericycle. The phloem is tetramerous, and, with the mesenchym, presents no points of contrast with the same structures in *Polygonum lapathifolium* (XIII:1).

The first stages of the transition concern the xylem alone. Duplication of the elements takes place in the upper part of the root, and the secondary rays of the xylem begin to disappear at the same time (XIII:2). This condition persists for a short time and is then followed by the equalization of the size of the elements, the disappearance of all but the primary ones and the prototracheids, and the ultimate arrangement of these in a single, radial series (XIII:3). During this time, the phloem and the mesenchym have remained passive. The mesenchym now intrudes itself between the central elements of the xylem, and, simultaneously, between the pericycle and the prototracheids. The xylem plates are then forced toward the centre of the cylinder, and the elements arrange themselves about the medulla more or less in the form of a V. Concomitantly, the opposite phloem strands, i. e., those separated by the uniseriate xylem plate (XIII:3), coalesce and the stele possesses now but two phloem masses, still separated by the mesenchym (XIII:4). This disposition is maintained without alteration until the cotyledons are reached, with the sole excep-

Digitized by Google

tion that the entire mesenchym of the stele is transformed into procambium, part of which becomes interfascicular cambium, and part, the originative tissue of the vascular system of the first internode.

The xylem and phloem masses reach the cotyledons without attaining the secantial disposition. At the moment of entrance, however, the phloem strands divide again into four, separated by the procambium. The two resulting vascular strands then assume the secantial disposition, and, one passing to either cotyledon, they are therein arranged according to the collateral type.

The final disposition of the vascular elements of the hypocotyledonary stele is the same in *Rumex* as in *Polygonum*. The method of attaining this, however, is very different. Instead of following the tetrarch type, the central cylinder assumes the diarch character, and the transition then occurs after the manner common to hypocotyls of this structure.

According to Gerard, the transition in *Rheum compactum* is different from that of *Rumex* or *Polygonum*. Not only do the four phloem strands divide to form eight, but each ray of the tetrarch xylem is split into two, resulting also in the formation of eight xylem strands. The secantial disposition is quickly passed through, each two adjacent vascular strands coalesce, and the "tigelle" attains the cotyledons characterized by four perfectly collateral bundles.

SUMMARY

Of all the various phases of the transition-region, there are four, which, by reason of their constancy within the species, and their great variation in higher groups, seem to be of essential significance. These are: (1) duplication of the xylem elements; (2) division, or non-division of the phloem; (3) the disposition of vascular elements upon entering the cotyledons; (4) the origin, or constitution of the cotyledonary trace. Of these, only the last, on account of its profounder significance, and greater constancy, is able to afford a satisfactory basis for the elaboration of certain types of transition. The other three,

Digitized by Google

by their not infrequent disappearance, or extensive modification, are unsatisfactory as fundamental characters for the analytical disposition of the manifold forms of transition. They are, however, of no inconsiderable service as cumulative characters, and may, moreover, be used as marks of subtypes.

The bundle-trace of the cotyledons may be constituted in three fundamentally different ways. It may be composed of the entire vascular system of the hypocotyledonary stele, holostelar; it may be constituted by those vascular strands, in which the prototracheids are the xylem elements, prototracheidal, or it may be formed from those bundles into which the metatracheids have passed, metatracheidal. The holostelar type is the most widely distributed. It is found in *Portulaca oleracea*, *Amarantus retroflexus*, *Amarantus albus*, *Beta alba*, *Phytolacca decandra*, *Polygonum lapathifolium* and *Rumex altissimus*. The prototracheidal trace is nearly as common as the holostelar: it occurs in *Dianthus sinensis*, *Silene armeria* *S. conoidea*, *S. otites*, and *Chenopodium album*. The metatracheidal type is rare. Of the plants investigated, it exists in but two, *Allionia hirsuta* and *Allionia nyctaginea*.

Duplication is a very constant feature of transition. It occurs throughout the Caryophyllales, except in those possessing a tetrarch xylem strand, i. e., in *Polygonum* and *Rumex*. It is never found in *Polygonum*: in fact, the method of vascular formation renders it unnecessary, if not impossible. It takes place to a slight extent in the three individuals of *Rumex altissimus* investigated. The peculiarly anomalous transition of this species presents many puzzling features, however, and, until further research has determined these, the actual existence of duplication is more or less doubtful.

The division of the phloem, which is essentially, at least, a correlate of xylem division, is found in about half the species studied. It occurs in *Dianthus sinensis*, *Silene inflata* (according to Gerard), *Portulaca oleracea*, *Allionia hirsuta*, *A. nyctaginea*, *Amarantus albus*, *A. retroflexus*, *Beta alba*, and *Chenopodium album*. In *Silene armeria*, *S. conoidea*, *S. otites*, and *Phytolacca decandra*, the phloem strands, instead of under-

Digitized by Google

going division, increase greatly in extent, and finally occupy the greater part of the periphery. Naturally, this circle of phloem is broken up at the passage of the bundle-trace into the cotyledons; by this time, however, the process has lost whatever of significance it may have once possessed. In *Polygonum* and *Rumex*, there is no necessity for a division of the phloem, since the number of secondary xylem plates corresponds to the number of phloem strands. This is not strictly true of *Rumex*, since the secondary xylem rays disappear, leaving but two secondary xylem plates. In correspondence with this, however, the four phloem strands coalesce into two.

The vascular elements of the hypocotyl reach the cotyledons in one of three conditions, centripetal, secantial, or collateral. The first two are but varying degrees of expression of incompleteness, and may be classed together as truncated transition; the latter may, in contradistinction, be called complete transition. The three are, of course, nothing but various expressions of the same structure and are not essentially distinct. They vary not only from species to species, but, sometimes, from individual to individual. Truncated transition is found in *Dianthus sinensis*, *Beta alba*, *Polygonum lapathifolium*, and *Rumex altissimus*. Complete transition occurs in *Silene armeria*, *S. conoidea*, *S. otites*, *Portulaca oleracea*, *Allionia hirsuta*, *A. nyctaginea*, *Amarantus albus*, *A. retroflexus*, and *Chenopodium album*. *Phytolacca decandra* presents both truncated and complete transition.

The extent of the transition-region is quite constant for the Caryophyllales. It commences usually in or near the colletal region, and terminates, almost without exception, at the insertion of the cotyledons. In consequence, the transition-region and the "tigelle" are almost invariably coincident, and the latter possesses, then, a peculiarly distinctive structure. In *Allionia hirsuta*, *A. nyctaginea*, and in some individuals of *Phytolacca decandra*, the transition operates almost entirely within the collet, and the anatomical features of the "tigelle" are in no wise characteristic, but correspond to those of the stem proper.

Digitized by Google

To summarise:

The transition-region of each species is reducible to a constant type, which is, however subject to certain, non-essential modifications. The number of types of transition in the Caryophyllales is three: holostelar, prototracheidal, and metatracheidal. The correspondence of histogenetic, and taxonomic characters is insignificant and valueless, except in the species. Even here, it is general.

II. THE ORIGIN AND DEVELOPMENT OF RADICELS.

HISTORICAL.

Nægeli and Leitgeb, in 1868, were the first investigators to pay especial attention to the details of the development of radicels. The plants studied were *Pontederia crassipes*, *Oryza sativa*, *Veronica beccabunga*, *Lysimachia thyrsiflora*, and *Nasturtium officinale*. In these, they considered the plerome, and periblem to be derived from the pericycle, while the calyptra was regarded as a derivative of the endoderm. They paid little attention to the dermatogen, looking upon it, perhaps, as the inner layer of the calyptra. Although they found, in *Limnanthemum vulgare*, that the calyptra increased in thickness by the tangential division of the dermatogen, they interpreted the process incorrectly.

Reinke, in 1871, stated that the origin of the radicel was always endogenous, and that it took place in the pericycle. He followed very exactly the division of the pericycle into three layers, but he erred in concluding that the dermatogen was constituted by the upper layer resulting from the division of the pericycle into two, while the division of the lower layer gave rise to the periblem and the plerome.

Janczewski, in 1874, denied the correctness of Reinke's conclusions, and laid down the principle that the plerome alone was constantly derived from the pericycle. As a result of his investigations, he described five types of radicellar origin.

In the first type, *Pistia stratiotes*, the pericycle gives rise to the plerome and periblem, while the dermatogen and the calyp-

Digitized by Google

trogen arise from the division of the endoderm into two layers; in the second, *Alisma*, *Sagittaria*, and *Zea*, the plerome and periblem are derivatives of the pericycle, while the calyptrogen is formed by tangential division of the outer layer of the periblem; in the third, *Raphanus*, *Fagopyrum*, *and Helianthus*, plerome, periblem, and calyptrogen arise from the successive division of the pericycle; in the fourth, Papilionaceæ and Cucurbitaceæ, the plerome alone originates from the pericambium, the periblem is formed from the successive division of the endoderm, and the calyptrogen is produced from the terminal cells of the periblem; in the fifth, both periblem and plerome arise from the pericycle. In the case of *Fagopyrum*, Janczewski speaks of the endoderm as forming a continuous layer about the radicel, the epigen, but he lays no emphasis upon the fact, and regards it apparently as of no importance,

Vonhoehne, in 1880, taking up the suggestion of Reinke that the exit of the radicel took place by the absorption of the tissue of the cortical cylinder, found that, as a result of chemical action, the cortical cylinder was digested and absorbed by the growing radicel.

Van Tieghem and Douliot, in 1889, in a memoir become classic, laid down the two fundamental principles, that the Dicotyledones present but a single type of radicellar formation, albeit this may show secondary variations, and that the radicel always proceeds, in its entirety, and in a manner essentially the same, from the pericycle of the mother root. Van Tieghem, moreover, was the first to follow the absorption of the cortical cylinder to its logical conclusion, and to distinguish between radicels with "poche digestive" (epigen), and radicels without "poche digestive". He also investigated the position of the rhizogenic arcs and their relation to the elements of the central cylinder, and traced the detailed development of radicels from simple and compound pericycles.

THE ORIGIN AND STRUCTURE OF RADICELS IN GENERAL.

The point of origin of the radicel is determined by the disposition of the xylem strands within the root. In the case of

Digitized by Google

diarch xylem strands, the disposition of the rhizogenic areas, and hence of the radicels, is either diplostichous, or monostichous. Where the xylem strand is tetrarch, or polyarch, the arrangement of radicels is isostichous. In the latter, which admits of little or no variation, except in those plants possessing pericyclar canals, the middle cell of the rhizogenic arc is exactly opposed to the prototracheid, and the radicels stand at equal distances from each other. Of the polyarch types, the tetrarch is the most common, and isostichy comes to mean quadriseriation in nearly all cases.

In the case of a root possessing a diarch xylem strand, the radicels may be either quadriseriate, diplostichous, or biseriate, monostichous: between the two are numerous transitional modifications. In typical diplostichy, the radicel lies directly in face of the mesenchymatous ray, and its basal cells rest on the one hand upon the prototracheids, on the other, upon the primary sieve-tubes. From this, it results that one-fourth of the pericycle is concerned in radicellar formation. When the quadrant contains an uneven number of cells, as is generally the case, the central one determines the axis of the radicel, and is the originative of the histogenic row: if the quadrant is composed of an even number of cells, the central two serve to determine the axis of the radicel.

In the majority of roots, however, the axis of the radicel is not in direct continuation of the mesenchymatous ray, but deviates from such a line, toward the xylem more frequently, but sometimes also toward the phloem. The angle of this deviation may be slight, in which case the quadriseriation of the radicels is not destroyed, or, on the contrary, it may be great, in which case the radicels tend to become more and more biseriate. In some instances, the angle of deviation reaches 45 degrees, and the radicel comes to be inserted upon the prototracheid, just as is the case in quaternary roots, though the radicels are now biseriate, or monostichous, instead of quadriseriate, isostichous.

The rhizogenic arc, then, is determined with reference to the above principles. It is constituted directly by the cells of

Digitized by Google

the pericycle when these are polyedric; if they are prismatic, each first undergoes division. In transection of the root, the rhizogenic area always appears as the rhizogenic arc, consisting of the cells of the pericycle concerned in the process.

The cells of the rhizogenic arc first elongate radially, and the central one or two divides transversely. Division follows quickly in the other cells of the arc, and the pericycle is then composed of two layers. The upper of these divides as did the pericycle, central cell first, lateral ones in quick succession. As a consequence, the young radicel consists of three layers, the lower, plerome, the middle, periblem, and the upper, dermatogen. The further development of each of these layers now devolves upon its initial cell, or histogen.

As a rule, the histogen of the plerome divides only transversely, and always in a basifugal direction. The segments also undergo transverse division for a short time, especially while the plerome is elongating rapidly, after which division is chiefly longitudinal. The formation of the pericycle of the plerome takes place usually by the longitudinal division of an apical segment of the histogen of the plerome. More rarely, the pericycle is developed from the ordinary segments of the histogen. The behavior of the dermatogenic histogen is essentially similar to that of the plerome. Its divisions are, however, always basipetal in direction. The first layer of the calyptra arises from the transverse division of the histogen of the dermatogen, and from the subsequent transverse division of the remaining cells of the dermatogen. Successive layers of the calyptra always arise below the first by the same process. As a consequence, the outermost layer, in which exfoliation always originates, is the oldest and the innermost, the youngest.

The histogen of the periblem divides almost invariably in a longitudinal direction. Ordinarily, one or two segments on either side of it share the same peculiarity for a certain length of time, so that the periblem is found to consist usually of but a single row of cells at the apex, while further down the sides, it is two-, or sometimes three-rowed. Both the lateral seg-

Digitized by Google

ments, and the histogen, however, divide ultimately to form either the endoderm and the exoderm of the cortical cylinder of the mature radicel, or their originative layers.

The exit of the radicel from the root was formerly supposed to result by the rupture of the cortical cylinder, caused by the rapidly growing tissue of the radicel. Van Tieghem was the first to deny this, and to point out the true method. He demonstrated that the process was a chemical one, in which diastasic solution and absorption of the adjacent cells occurred. He, moreover, divided radicels into two groups, according to the method by which this absorption took place. In some instances, the outer layer, or layers, of the radicel itself performs this function. In this case the calyptrogen is often more highly developed for this process, though quite as frequently, solution and absorption of the circumjacent layers are carried on by the dermatogen alone. In other instances, the endoderm undergoes special modification to become a particular digestive organ. At the same time that the primary layers of the radicel are being formed, the cells of the endoderm undergo repeated radial division. In addition to this, the cells increase considerably in size, and are distinguished by the dense protoplasm and large nucleus. As the radicel grows, the accommodation of the transformed endoderm, or epigen, to it results by the appearance of new transverse divisions, and this peculiar digestive layer accompanies the radicel until the latter has penetrated the cortical cylinder, when it in its turn is digested and absorbed. In some plants, division of the endoderm takes place tangentially as well, and the result is a several-layered, or compound epigen, similar in behavior and function to the simple one.

As has been stated before, Van Tieghem is inclined to group radicels into two classes, based upon the presence or absence of the epigen. That this organ is purely local, if not sometimes, even, entirely accidental, is shown by the fact that it may exist in one of two nearly related genera, and be entirely lacking in the other. Even more; *Chenopodium album* sometimes possesses an epigen, and is at other times deprived of one.

Digitized by Google

Moreover, in the Chenopodiaceæ, especially, the epigen is a particularly variable, and inconstant structure. According to Van Tieghem, it is lacking in *Chenopodium album*, *quinoa* and *nitrariaceum;* in *Chenopodium*, when present, it consists of but four cells; in *Salsola tragus*, and *Acnida cannabina*, of but three; in *Beta maritima*, and *Kochia eriophora*, the epigen persists only until the middle of the cortical cylinder; in *Beta alba*, it is not absorbed until the radicel has made its exit, while in *Atriplex tartarica*, *Axyris amarantoides*, and others, it remains as a covering to the radicel for some time after its exit. It is, hence, easily seen that the possession, or deprivation of an epigen is of no particular significance. The two conditions in no way correspond to two distinct and different structures, but merely to very various degrees of expression of the same structure.

The correlation of the peculiarly serial zones of the radicel, dermatogen and periblem, with the more or less irregularly disposed mesenchymatous tissue of the root is effected by means of an especial cell (really, of course, a circle of cells), called by Van Tieghem, the epistele. It is the basal cell of the upper layer formed by the bipartition of the pericycle, and may be distinguished as soon as the upper layer is divided into periblem and dermatogen, a process which takes place in every cell except the basal one. Van Tieghem defines the epistele as the place where the periblem and dermatogen "se confondent." In the mature radicel, the epistele is to be distinguished from the basal cells of the plerome only by its position, and subsequent behavior. After a certain time, it undergoes transverse division, and of its two segments, the inner becomes a component of the periblem, the outer, a constituent of the dermatogen. In some cases, these two segments undergo further radial division, and the transition from dermatogen and periblem to the tissue of the root is more gradual still. In one or two rare instances, the epistele appears to consist of two or more cells, which function practically as does the simple epistele.

Digitized by Google

DETAILS OF ORIGIN AND STRUCTURE.

CARYOPHYLLACEÆ.

Dianthus sinensis. The cortical cylinder of the root possesses a diarch xylem strand separated from the two plate-like phloem strands by means of two or three layers of mesenchym. In the unmodified central cylinder, the prototracheids usually lie against the pericycle; at the place of origin of a radicel this is always the case. The entire cylinder is surrounded by endoderm, consisting ordinarily of 14-20 polyedric, or slightly rounded cells, which contain a resting nucleus imbedded in a small amount of protoplasm.

At the point of radicellar origin, an uneven number of cells of the pericycle, 7, 9, 11, or even more, elongate radially, and, beginning with the central one, divide transversely to form two layers. As is normal for Dicotyledones, the inner layer gives rise to the plerome, while the outer divides again almost immediately to form the periblem and the dermatogen. At the same time, a basal cell is cut off from the histogen of the plerome, and these four cells, the three histogens and the basal cell, come to lie in the axis of the radicel (XIV:2). Concomitantly, an even number of cells of the endoderm just without the rhizogenic arc become densely filled with protoplasm, and they immediately begin to function as the epigen ("poche digestive" of Van Tieghem). Normally for *Dianthus sinensis*, the epigen persists as a single layer of cells covering the radicel until the latter reaches the exterior, when it is at once absorbed. Rarely, however, it is possible that the cells of the endoderm may divide transversely as well as radially, thus giving rise to a compound epigen. Van Tieghem has already pointed out that in some plants the cortical layers next the endoderm take part in the formation of a compound epigen. It would not be surprising, then, to find such a structure arising from the endoderm alone, as sometimes seems to be the case (XIV:2).

At this period, there is no sharp line to be drawn between the three zones, and the epistele is not yet to be discerned. The rapid elongation of the radicel, however, soon tends to

Digitized by Google

accentuate the basipetal and the basifugal division of the histogen of the dermatogen and plerome respectively, and these two zones become easily distinguishable from the periblem. At the same time, the epistele is first to be seen readily, though its formation is really anterior (XIV:1). At this period, the calyptrogen, or first layer of the calyptra, is formed. Its origin is due to a single basipetal division of the dermatogenic histogen, followed by a similar division of a certain number of segments of the latter, in the present instance, four.

The further development of the radicel follows the type. By the time that the tip of the radicel has reached the exterior, the calyptra consists of three or four layers, in the outermost of which exfoliation has all but begun. The pericycle of the plerome has become set off as a single layer of elongated, prismatic cells, though the axial row of cells shows no indications of spirals. The terminal segments of the periblem, moreover, remain undivided and, as a consequence, the periblem is so far undifferentiated into endoderm and exoderm. The three histogens again assume a more nearly serial arrangement, which they maintain.

The xylem strand in the root of *Dianthus* is binary, and, according to Van Tieghem's conclusions, the arrangement of the radicels should be diplostichous. Such is normally the case; the rhizogenic arc extending from the prototracheid of the xylem strand to the primary sieve-tube of the phloem strand, thus being placed directly in front of the mesenchym. In some cases, however, one-half of the number of cells of the pericycle take part in the formation of the radicel, and the rhizogenic arc extends from prototracheid to prototracheid. At first glance, this appears to indicate biseriate arrangement of the radicels and such, in fact, is what Clos had already pronounced it to be. On closer examination, however, it is seen that it is not the central cell of the rhizogenic arc, but one nearer this or that prototracheid that determines the histogenic series of the radicel. Thus, while the angle of deviation from the normal position is almost 45 degrees, nearly resulting in the opposition of rhizogenic area and of phloem,

Digitized by Google

and in a biseriate arrangement of the radicels, yet, the quadriseriate radicels never assume a perfectly biseriate disposition.

Silene otites. The structure of the central cylinder of the root is essentially similar to that of *Dianthus sinensis.* The xylem strand is diarch and is separated from the broad phloem strands by the two-layered mesenchym. The location of the rhizogenic area, and the formation of the three zones of the radicel are likewise identical. In the earlier stages of the differentiation, oblique segmentation is so frequent that it becomes almost impossible to distinguish the histogens, which, for the most part, are exactly seriate, and, as in *Dianthus sinensis*, are prolonged downward into the basal cell of the plerome.

There is no epigen in *Silene otites.* The endoderm, instead of being transformed to constitute a nourishing envelope, is quickly absorbed by the dermatogen, and the developing radicel comes to lie directly against the cells of the cortical cylinder. The calyptrogen is early cut off from the dermatogen, and its comparatively large extent is no doubt due to the fact that hereafter, i. e., until the radicel leaves the root, it is to function as the digestive and absorptive layer of the radicel (XIV:4). Naturally, this function must be performed by the dermatogen for the basal portion, but, since diastasic solution and subsequent absorption are so much more active at the apex, the calyptrogen may be regarded as the real organ of this process.

The differentiation of the layers of the radicel, though by no means sharp, is quite exact. In the comparatively young plerome, the axial row is already differentiated, and the pericycle is distinguishable as such at the apex of the cylinder, at least. More unexpected is the very early separation of the periblem into endodermic and exodermic layers, a step which appears in *Dianthus sinensis* only after the radicel has left the root. The significance of the early and extensive delimitation of the calyptrogen has already been discussed.

At the moment when the radicel escapes from the root, its structure may be characterized, generally, as follows: The plerome consists, ordinarily, of five or six layers of typically

Digitized by Google

elongated cells, surrounded by a pericycle, whose cells are polyedral, rather than prismatic. As far as could be determined, the single histogen occupies the very apex of the plerome, and the terminal cells of the pericycle are lateral segments of it, not the derivatives of an apical segment of it, as is the case in *Dianthus sinensis*. The periblem, as stated above, is ordinarily separable into the originative layers of endoderm and exoderm. This, however, is not always true. In some radicels it is still simple at the apex, as in *Dianthus*. The dermatogen offers nothing of especial interest, except that it is composed of remarkably large, cuboidal cells, which also characterize the periblem. Its histogen, though small, is distinct, and, with its derivatives, forms a very perfect series with the histogen of the periblem and of the plerome. The calyptra consists of three layers; an inner one still in the process of formation, a middle one already well-differentiated, and an outer, earlier one, the diastasic envelope. The latter covers the entire upper half of the radicel, and is so compact that it persists intact in radicels that have pushed far beyond the root. Not a trace of exfoliation has been found in any of the sections examined. The appearance of this outer layer of the calyptra at this time is characteristic. It is of a peculiar, flabelliform shape, due to greater increase in size of the upper and terminal cells, an increase that is gradually lost toward the lower end.

The insertion of the radicels is typically diplostichous. Normally, however, the angle of deviation toward the prototracheid is so great that the paired series are almost coincident, as was demonstrated in *Dianthus*, where the deviation was, however, toward the protophloem. In one instance, moreover, the deviation is so great that the radicel is inserted directly in front of the prototracheid, which, with its arch, lies in the continuation of the axial row of the plerome.

Clos, basing his conclusions upon external evidence alone, ascribed biseriate radicels, as well as quadriseriate, to Caryophyllaceæ. Van Tieghem denies absolutely the existence of biseriate radicels, and states that Clos' error was due to lack of histological evidence. He admits, however, that externally

Digitized by Google

the radicels may appear biseriate, and that internally the angle of deviation may vary through very wide limits: virtually an admission, notwithstanding his statements, that the angle of deviation may become 45 degrees, resulting in the biseriate disposition of the radicels, just as in the case mentioned above.

Silene conoidea. The structure of the central cylinder is practically identical with that of *Silene otites.* The early stages of the radicel are essentially those of *Dianthus sinensis* (XIV:2), with the one important exception that, as in *S. otites*, the epigen is entirely lacking. The histogens of the plerome and periblem are remarkably large and distinct. The cells of the dermatogen are peculiarly cubical in shape, resulting from the fact that they function, until the separation of the calyptrogen, as the diastasic layer of the radicel.

In the comparatively few instances noted, the insertion of the radicels was biseriate, the long axis of the xylem strand lying directly in the continuation of the axial row of the plerome, and the exterior basal cells resting exactly upon the primary sieve-tubes of either phloem strand.

Silene armeria presents the same general, histogenetic features as does *S. conoidea.* It differs merely in the diplostichous insertion of the radicels.

The Caryophyllaceæ are characterized by a diarch xylem strand, and, in consequence, by quadriseriate radicels, i. e., by diplostichous arrangement of the radicels. In this family, then, the radicel is normally opposite the mesenchymatous ray, and is limited on the one hand by the prototracheid, on the other, by the primary sieve-tube. In any genus, or species, or sometimes in a single individual, the axis of the radicel may deviate from coincidence with the ray of the mesenchym, and approach either protoxylem or protophloem. When this deviation is slight, the quadriseriate disposition is still evident, but as the angle of deviation approaches 45 degrees, the paired radicels come to lie directly over each other, either in face of the phloem, as in *Dianthus sinensis*, and *Silene armeria*, or in front of the xylem, as in *Silene otites* and *Silene conoidea.*

Digitized by Google

As Van Tieghem has demonstrated, the presence or absence of epigen in this family is not at all constant for groups higher than genera; it may be found to hold only for species. He has shown its absence in *Silene nocturna* and *integrifolia*, to which should be added *Silene armeria*, *conoidea* and *otites*, and its presence in *Dianthus viscidus*, beside which should be placed *D. sinensis*.

The histogens of the three zones of the radicel are apparently always single. In the periblem, there sometimes appears to be three, or even as many as five; these are, however, simply the undivided segments. The number of layers in the calyptra is ordinarily three, though this is entirely dependent upon the age of the radicel, and upon the presence or absence of exfoliation.

There seems to be two methods of formation for the pericycle of the plerome. In the first, in *Dianthus*, the terminal cell of the pericycle is cut off as an apical segment of the histogen, while the adjacent cells are cut off similarly from the histogenic segments. In the second, noted for *Silene*, the histogen itself occupies the apex of the plerome, and the uppermost segments cut off from it laterally go to constitute the pericycle. Van Tieghem does not make mention of two such processes in his text, but some of his drawings evidence the one or the other very clearly.

Portulacaceæ.

Portulaca oleracea. The xylem strand of the root is diarch in the younger plants; in the older ones, especially in the transition-region, it becomes more or less completely tetrarch. It is surrounded by a broad band of mesenchym, composed of large, polyedric cells. The phloem strand is located on either side of the mesenchym, as an elongated plate of slightly differentiated cells.

The point of origin of the radicel may be directly in face of the mesenchymatous ray, resulting in diplostichy, or it may be directly in front of the prototracheid, producing biseriate disposition of the radicels. The latter seems more often the case

Digitized by Google

in young roots, where secondary changes have not yet taken place, while in older roots, where the disposition of the elements has been altered, quadriseriate arrangement seems to be the rule. In the same maturer roots, the radicels often arise in the same plane, resulting in the formation of a compound radicel, which appears to be placed directly in front of the phloem. Such an arrangement is, however, easily reducible to diplostichy, since each component radicel of the compound one is located in front of the mesenchymatous ray.

A special, diastasic layer is lacking in *Portulaca oleracea*. The endoderm is quickly absorbed by the dermatogen, which performs this function until the differentiation of the calyptrogen. The number of layers of the calyptra is ordinarily three, which extend almost to the base of the radicel.

The number of histogens in the periblem, contrary to the rule, is two; both dermatogen and plerome, however, have but a single one (XV:1).

Nyctaginaceæ.

Allionia hirsuta. The xylem strand is diarch, each arch consisting of four elements, united by a larger one in the centre. The prototracheids are separated from the simple pericycle by two or three layers of small cells. The mesenchym is very abundant and consists of five or six rows of small, polyedric cells, separating the large sieve-tubes of the phloem from the xylem.

The number of cells of the pericycle taking part in the formation of the radicel is nine, out of a total of forty. Two of the cells lie on one side of the prototracheid, and seven on the other. In consequence, the disposition of the radicels is diplostichous, with an inclination of about thirty degrees toward the xylem. In one instance, however, that of a mature radicel, the fifth, or middle cell, of the rhizogenic arc was directly in line with the three prototracheids, thus indicating a monostichous, or biseriate arrangement of the radicels.

As normally, the nine cells of the rhizogenic arc divide transversely to form two layers, and the upper of these two

Digitized by Google

divides again, forming the dermatogen, periblem and plerome. The fifth, or middle cell, gives rise to the histogenetic row of the radicel, and as a consequence, each zone possesses but a single histogen. The first cell of the calyptrogen is cut off as an apical segment of the histogen of the dermatogen, and this gives origin to the lower layer of the calyptra, which is composed of elongate, plate-like cells, extending half-way down the radicel.

The cells of the endoderm, without undergoing any special modification, divide radially, and accompany the growing radicel as the epigen. This layer differs from the epigen of *Dianthus sinensis* in its narrow, elongated cells (XV:2), a condition, perhaps, induced by the pressure experienced in passing through the cortical cylinder. So far as *Allionia* is concerned, the epigenic layer always remains simple, contrary to the rule in some genera of this family.

Contrary to what Van Tieghem has postulated for the nature and behavior of the epistele, in *Allionia hirsuta* it appears to consist of at least two cells, one of which cuts off segments to form a continuation of the dermatogen, while the other assists in the formation of the periblem. If the epistele is but a single cell, its identity is not easily established among the two or three cells, which occupy this particular region.

At the time of the exit of the radicel from the root, it is characterized by the presence of five very distinct layers. The outermost of these, the epigen, consists of a single layer, the disintegration and absorption of which has already begun at the apex (XV:2). Below this is the calyptra, comprising four layers, the outer cells of which have undergone exfoliation even before the radicel has pierced the epiderm of the root. Beneath the calyptra and originative of it, is the dermatogen, a single layer of large, cuboidal cells terminated near the base of the radicel by the epistele. The apex of the periblem is terminated by a row of three cells, the large pentagonal histogen and its two lateral segments. From each of the latter arise two rows of cells, which become three in number sometime before the epistle is reached. The plerome consists of a

Digitized by Google

remarkably well-defined axial row surrounded by three layers of cells, in their turn enclosed in the simple pericycle. The latter takes its origin from the longitudinal division of an apical segment of the pleromal histogen.

The radicellar formation of *Allionia nyctaginea* agrees completely with that of *Allionia hirsuta*. No case of genuine monostichous insertion of the radicels has been found, however.

Amarantaceæ.

Amarantus albus. The xylem strand of the root is diarch, and consists of eleven elements, of which the prototracheids lie directly against the pericycle. The mesenchym consists ordinarily of one layer of cells, more rarely of two. The phloem strands are small, containing only a few elements. The pericycle is simple and comprises about 20 cells.

Of the whole number of cells of the pericycle, but five commonly take part in the formation of the radicel. In all the pericycles examined, the number of cells between prototracheid and primary sieve-tube was uniformly five. Since the odd, or middle cell of the rhizogenic arc gives rise to the histogenic row of the radicel, it follows that the radicel is inserted exactly in face of the mesenchymatous ray, and forms an angle of 45 degrees with both xylem and phloem. Such an arrangement is typically perfect diplostichy, and seems to be constantly characteristic of *Amarantus albus*.

The origin of the three zones of the radicel from the pericycle is entirely normal. The endoderm, however, is not converted into epigen, but is absorbed by the calyptrogen. That the latter almost solely performs the diastasic function is beyond doubt, since it is only after its differentiation from the dermatogen that the endodermis begins to disintegrate. The histogens of all three zones are unpaired. The behavior of the epistele is apparently according to the rule. The calyptra usually consists of two or three layers, the first of which, in its diastasic function, covers the upper half of the radicel.

The formation of radicels in *Amarantus retroflexus* agrees in all particulars with that in *Amarantus albus*.

Digitized by Google

Van Tieghem assigns two histogens to the periblem in *Amarantus paniculatus*, *hybridus*, *chlorostachys*, *speciosus* and *atropurpureus*. In *Amarantus albus* and *retroflexus*, there is but a single one, apparently. In the same plants he states that the delimitation of the calyptrogen takes place just before the exit of the radicel, while in those here investigated, the calyptrogen is cut off before the absorption of the endoderm.

Chenopodiaceæ.

Beta alba. The xylem strand is regularly diarch, each arch consisting of four to six elements. The mesenchym comprises one, rarely two layers, which passes almost insensibly into the phloem strands. The pericycle is simple, and usually contains about 40 cells.

Of the whole number of cells in the pericycle, seven are generally concerned in the formation of the rhizogenic arc. Three of these are located on one side of the prototracheid, and four on the other. In consequence, the odd, or middle cell, lies immediately to the right, or left of the prototracheid, and the angle of deviation approaches 40 degrees. No case was observed, however, where this angle becomes 45 degrees, so that diplostichy is characteristic of the radicels.

The transformation of the endoderm into epigen is a comparatively slow process. The cells enclosing the tip of the radicel are first changed, and modification then takes place in a basipetal direction. In the stage represented in figure 1, plate XVI, the cells of the endoderm at the base of the radicel are still undergoing division. From their small size and considerable number, the cells of the epigen are with difficulty distinguished from the cells of the dermatogen. Their origin is proved beyond doubt, however, by their continuity with the cells of the endoderm. Although no instance of complete bipartition of the epigen has been found, so many of its cells show transverse division, that no doubt there are cases in which it is really two-layered.

The behavior of the epistle is evolved in very considerable uncertainty. As has been already suggested for *Allionia hir-*

Digitized by Google

suta, it appears to consist of at least two cells. It may be possible, however, that primary division takes place at a time when the epistle is not to be distinguished from the adjacent cells.

The histogen of both plerome and dermatogen is always unpaired. The same is apparently true of the histogen of the periblem, though, in some cases, there appears to be a second present. The calyptrogen is early cut off from the dermatogen as a thin plate of cells, extending about half way down the radicel. The differentiation takes place slowly: the pericycle and axial row do not appear until just before the exit of the radicel from the root.

Chenopodium album. The disposition of the elements of the central cylinder is very similar to that of *Beta alba*.

Of the 20 cells of the pericycle, five are concerned in the formation of the rhizogenic arc. Of these, three are on one side of the prototracheid, one on the other side and one directly in front of it. As in *Beta*, the odd cell, the initial of the axial row of the radicel, lies immediately to the right or left of the prototracheid, and the arrangement of the radicels is atypically diplostichous.

The number of cells of the endoderm, which take part in the formation of the epigen, is normally four. As the radicel grows older, this number sometimes increases to five or six. In all cases, however, the lower part of the radicel is uniformly destitute of an especial diastasic layer (XV:4).

The epistele is very distinct, even as early as the time of origin of the epigen, and its behavior is apparently quite normal.

Van Tieghem assigns an epigenic layer to *Beta alba*, but he states that *Chenopodium album* is destitute of one. In certain genera of Chenopodiaceæ, he finds the epigen developed in very different degrees, and persisting for a very variable length of time. It may, therefore, be possible that the same genus, or the same species even, may, at one time, develop a particular diastasic layer and, at another time, be entirely destitute of such.

Digitized by Google

Phytolaccaceæ.

Phytolacca decandra. The xylem strand is diarch, each arch comprising eight to ten elements. The mesenchym is a broad band of four or five layers of cells, partially enclosing the nearly circular strand of phloem.

The number of cells of the pericycle concerned in the formation of the rhizogenic arc is seven, one of which lies on one side of the prototracheid, and six on the other. The disposition of the radicels is in consequence almost perfectly diplostichous. The rhizogenic arc, as above, gives rise to the three primary layers of the radicel, two of which, plerome and dermatogen, are characterized by a single initial, while the third, periblem, possesses two histogens. The plerome is a broad cylinder, consisting of an axial row and four or five enveloping layers, the outermost of which is slowly differentiated into the pericycle. The periblem comprises but a single row of cells at the apex; below, this layer is increased to two. The calyptra is especially well-developed, consisting of three or four layers, which become as many as five or six by the time that the radicel is ready to leave the root.

The endoderm surrounding the young radicel is completely differentiated to form the epigen. Transverse divisions arise in it early, and the mature epigen then contains at least two layers.

Polygonaceæ.

The structure, position, and development of the radicels of *Polygonum lapathifolium* are identical in all respects with those of the radicels of *Rumex altissimus.*

Rumex altissimus. The xylem strand is tetrarch. Each arc consists of three or four elements, united in the centre by a single large vessel. The number of phloem strands is also four, separated from the xylem by two rows of mesenchym. The pericycle is simple and consists of about 40 cells.

As Van Tieghem has pointed out in the case of all quaternary roots, the disposition of the radicels is isostichous, i. e., the odd cell of the rhizogenic arc is directly opposed to the

Digitized by Google

prototracheid. If two radicels arise at the same level, they are not confluent as in the diplostichous arrangement, but stand at right angles to each other. The number of cells of the pericycle concerned in the formation of the rhizogenic arc is ordinarily seven.

The whole of the endoderm covering the radicel is modified by radial divisions into a compact epigen, which persists for some time after the radicel has left the root. The epigen never manifests any transverse divisions, and, in consequence, always remains simple.

The epistele is very prominent, existing as a cell which stains but slightly in the midst of much smaller cells, staining a deep red. The periblem possesses two initials, and is but one-rowed at the apex. Further down, it is two-rowed, and before it reaches the epistele, the number of rows becomes three. The histogen of the dermatogen and of the plerome is unpaired. The calyptrogen is strongly developed, consisting of three or four rows of cells, the outer of which covers the upper two-thirds of the radicel.

CONCLUSIONS.

From the foregoing data, Van Tieghem's conclusions that the radicel proceeds always and entirely from the pericycle, and that there is but a single type of radicellar formation for Dicotyledones receive new confirmation. It may, at first, seem somewhat difficult to reduce the various modifications to one type, but a careful study of each makes it evident that modification has taken place almost exclusively in the rather non-essential features of the process. Thus, while there may be considerable differences with respect to the arrangement of the radicels, the number of initials in the respective layers, the formation of the epigen, or the behavior of the epistele, there is absolute unanimity with regard to the originative layer, the method of origin, the number of primary layers, the mode of exit, etc.

The Caryophyllales are characterized by the possession of a simple pericycle and a diarch xylem strand. Exceptions to

Digitized by Google

the latter are found in the Polygonaceæ, *Rumex* and *Polygonum*, where the xylem is tetrarch. Diplostichy, or monostichy of the radicels is the rule, though isostichy is alone found in the two genera just mentioned.

The zones of the radicel are derived typically from a single initial, though in a few rare cases, *Beta*, *Amaxantus*, the periblem possesses a paired histogen. The presence of a definite and well-developed calyptra is characteristic of the whole order.

As has already been mentioned, inconstancy in the formation of the epigen is characteristic of this order. The epigen is found in seven genera, and eight species, and is lacking in three genera and six species. Its instability within family, genus, and even species has also been sufficiently demonstrated.

III. THE APICAL GROWTH OF THE STEM.

HISTORICAL.

Hofmeister, in 1851, was the first investigator to study the structure of the apical region of the Phanerogams. Influenced by his researches in the Pteridophytes and Gymnosperms, he was led to conclude that the Phanerogams were likewise characterized by a single apical cell. His discoveries were made upon *Robinia*, *Elymus*, *Iris*, *Acer* and *Fraxinus*, in each of which he thought to see a single terminal cell, in some cases, cuneiform, in others, prismatic. In 1859, Hofmeister figured a terminal cell in the embryo of *Loranthus*, and of *Lathraea*, without making any definite statement as to whether the mature plant grew in the same fashion.

Caspary was the first to combat the views of Hofmeister. In his studies of Hydrillaceæ in 1858, he gives no definite expression to the apical region of *Philotria canadensis*, but, a year later, he assigned three initials to *Aldrovandia vesiculosa*, each of which is originative of a distinct layer, or zone.

Sanio, in 1864-65, found in the apex of *Hippuris vulgaris* two meristem layers, always dividing perpendicularly to the surface, which he regarded as giving origin to the leaf. Beneath these, he recognized the central cylinder, to which he

Digitized by Google

assigned no initial, although noticing the fact that both dermatogen and periblem took their origin each from a particular cell.

N. J. C. Mueller, in 1866, investigated and figured, among others, *Dianthus barbatus*, *D. plumarius*, *Fraxinus excelsior*, and *Viscum album*. To *Fraxinus excelsior*, he assigned a single initial, although his figure contradicts his statement. Douliot, from Mueller's figures, credits him with attributing three initials to *Dianthus barbatus*, and one to *Dianthus plumarius*. These drawings, which, together with those of *Viscum album*, show clearly the differentiation into plerome, periblem and dermatogen, might as easily be interpreted to represent an apex possessing two histogens. Whatever construction may be placed upon some of his figures, there can be no doubt that Mueller stood with Caspary for the existence of more than one initial in the apex of Phanerogams.

Hanstein, in two treatises, 1868, '70, first extended his researches over a large number of genera. He proved conclusively that, not only was the apex of the plant furnished with several initials, but also that these initials were to be found in the very young embryo, which Hofmeister and others had thought grew by the division of a single terminal cell. He distinguished the three primary layers of the embryo, and of the vegetative point, as dermatogen, periblem and plerome. It was by reason, however, of the constant presence of these three layers in the apex that he fell into a very considerable error. He thought that each layer, or zone, had its origin in an initial peculiar to itself, and, as a consequence, was led into attributing three histogens to all Phanerogams, a misinterpretation first corrected, as will be seen below, by Douliot.

Hanstein's opinions have been opposed by Pringsheim, Westermeier, Naegeli and others; on the other hand, his theory has been supported by Voechting, Kubin and Mueller, Haberland and Groom.

In 1890, Douliot, in a somewhat exhaustive memoir, confirms, in general, Hanstein's conclusions. While admitting regular occurrence of three layers in the apex, however, he

Digitized by Google

finds that, by reason of the community of origin of periblem and plerome, the number of initials is sometimes decreased to two, one for the dermatogen, and one common to both plerome and periblem. His investigations, which are based upon a number of genera greater than all those before studied, are conclusive and permit of the postulation of the general principle that the Phanerogams are characterized by an apical region, possessing two, sometimes three initials, but never a single apical cell.

Douliot's conclusions afford a suggestion of the possible taxonomic significance of the variation in the number of initials of the apex, and will be given here in brief.

"In the Gymnospermæ, the stem has always but a single initial cell at its summit. With Monocotyledones, the case of two initials is more frequent, that of three initials less frequent".

"In the Apetalæ, out of six examples, four have but two distinct initials; of the fifteen families of Dialypetalæ Hypogynæ studied, five possess a stem with two initials; the five families of Dialypetalæ Epigynæ have always shown three distinct histogens; finally, among the Gamopetalæ, the Plantaginaceæ alone are characterized by two initials."

"It may then be said that in the majority of Dicotyledones, the stem is terminated by three initials, and, in a small number, by two initials only; in the latter case, one initial is common to the periblem and to the plerome cylinder".

DETAILS OF THE APICAL GROWTH IN THE VARIOUS FAMILIES.

Caryophyllaceæ.

Dianthus sinensis. The apex of the seedling is characterized by two histogens, the upper of which gives rise to the dermatogen, or epidermis, the lower to both periblem and plerome. The latter is the terminal cell of the tissue beneath the dermatogen (XVII:1).

In the seedling, the periblem is always simple; it consists in the mature plant, ordinarily, of three or four layers.

Silene armeria. The three layers of the apex are more or

Digitized by Google

less sharply set off from each other. Contrary to the case in *Dianthus sinensis*, the periblem is two-rowed almost from the first. Hence, the initial of the periblem is distinct from that of the plerome, and the apical region is characterized by three histogens (XVII:2).

Silene otites. The constitution of the apical region is similar to that noted for *Dianthus sinensis*. The periblem consists of a single layer, scarcely to be distinguished, on account of its imperfect continuity, from the plerome. The two inner layers, periblem and plerome, in consequence, possess a single initial, which gives rise to its segments by longitudinal division (XVII:3).

According to Douliot, N. J. C. Mueller ascribes three histogens to *Dianthus barbatus*, and one to *Dianthus plumarius*. Hanstein assigned, in general, three initials to *Dianthus* and *Silene*, while Douliot finds in *Dianthus calocephalus* but two. There is but little doubt that Mueller erred in giving *Dianthus plumarius* a single initial, so the Caryophyllaceæ investigated may be divided into two classes, the one characterized by an apical region with three histogens, the other possessing an apex with but two. In the former would fall *Dianthus barbatus* and *Silene armeria*, in the latter, *Dianthus calocephalus*, *sinensis*, and *Silene otites*.

Portulacaceæ.

Portulaca oleracea. The apex of the seedling possesses two histogens, one for the dermatogen, and one common to both periblem and plerome. The latter, which is particularly large and conspicuous, forms its segments by longitudinal division. The periblem is one-layered and, except at the apex, is indistinguishable from the plerome (XVII:4).

On the contrary, the apex of a mature stem or branch shows three histogens, and three quite distinct tissue-zones. The periblem is two-rowed, and possesses its own initial. The initial of the plerome now divides transversely, instead of longitudinally as above (XVII:5). It has been impossible to make out clearly the structure of the leaf-evaginations of the apex on

Digitized by Google

account of the torsion of the tissue. They seem to have, primarily at least, but two histogens, both plerome and periblem taking their origin from the inner.

So far as could be ascertained, the apical region of the Portulacaceæ has never before been investigated, so that it is impossible to confirm by the work of others these two very diverse apex structures in the same species.

Nyctaginaceæ.

Allionia hirsuta. The apex of the seedling stem possesses two initials. The initial of the dermatogen is indistinct, and scarcely to be distinguished from its segments. That of the periblem and plerome is, on the contrary, extremely large and conspicuous. It gives rise by longitudinal division to segments which constitute the periblem and by transverse division to the elements of the plerome cylinder. An especially prominent feature of the apical cone is the sharp delimitation of the periblem which consists of a single layer increased to two on the sides (XVII:6).

Allionia nyctaginea is in complete accord with *Allionia hirsuta*, so far as the number and behavior of the histogens is concerned. In no case, however, was the common histogen so characteristically conspicuous, nor was there evident any such sharp differentiation of the periblem (XVII:7).

Amarantaceæ.

Amarantus albus. The number of histogens in the apical cone is two; as usual, one for the dermatogen, and one common to the periblem and the plerome. The latter follows the rule, and divides longitudinally to form its segments. The periblem is differentiated very late, and is never sharply delimited, except in old stems (XVIII:1).

The constitution of the apical region of *Amarantus retroflexus* is identical in all respects with that of *Amarantus albus* (XVIII:2).

Digitized by Google

Chenopodiaceæ.

Chenopodium album. The apex of both seedling and mature plant is characterized by the possession of two initials, one for the dermatogen, and one common to plerome and to periblem. The latter, instead of lying next the dermatogen, as is usually the case in apices having but two histogens, is situated in the next lower layer, and its lateral segments give rise to the second layer of the periblem (XVIII:3).

Beta alba. The initial of the dermatogen is not at all prominent, and is to be easily recognized only in very young apices. The plerome and periblem have a common histogen, situated as in *Chenopodium album*, in the second layer of the periblem. In apices of large seedlings, the two layers of the periblem are especially conspicuous. In very young seedlings, and in young branch-buds, there is but a single layer. Moreover, where the two-rowed periblem leaves the apex to enter the leaves, it suddenly narrows to a single row, the cells of which alternate with those of the dermatogen (XVIII:4).

The growth of the histogen common to periblem and plerome is similar to that of the initial of the dermatogen and its division is, in consequence, longitudinal.

No other genera or species of Chenopodiaceæ have so far been investigated with respect to the behavior of the apical region. To generalize from the results obtained in the two species mentioned above; the apex of the stem of Chenopodiaceæ is characterized by the possession of two histogens, the inner of which always lies in the second layer of the periblem.

Phytolaccaceæ.

Phytolacca decandra. The apex belongs to the normal type, in that it possesses two histogens, one peculiar to the dermatogen and the other common to plerome and periblem. Both histogens show division in the longitudinal direction (XVIII:5).

The disposition of the periblem is two-rowed as in the Chenopodiaceæ, but contrary to the case in that family, the common initial is apparently always located in the outer layer.

Digitized by Google

The apex of the various shoot-members of the plant seems always to be characterized by identity of structure, and of behavior.

Polygonaceæ.

Polygonum lapathifolium. The apex of the stem possesses two histogens, and has but one layer in the periblem. The initial common to both periblem and plerome differs from that in the other families of the Caryophyllales having two histogens, in its location. Instead of being a component cell of the periblem, it occupies a position more or less superior to the latter, and simulates a single apical cell in appearance. Its division is, however, longitudinal and normal (XVIII:6).

Rumex altissimus. The common initial for the plerome and periblem behaves very differently from that of *Polygonum lapathifolium.* Division of it takes place transversely, and it gives rise, in consequence, to the two layers of the periblem (XVIII:7).

Hanstein has assigned three histogens to *Polygonum.* Douliot finds in *Polygonum amphibium* but two, the inner of which is identical in location and behavior with that of *Polygonum lapathifolium.* Notwithstanding the difference in the method of division of the inner histogen in *Rumex* and *Polygonum*, the Polygonaceæ are regularly characterized by the possession of two histogens.

Conclusions.

Of the thirteen species studied, eleven possess two initials, one possesses three initials, and one has two initials in the seedling, and three in the mature plant. In the cases of three initials, the periblem is constantly two-rowed, apparently a necessary concomitant of this structure of the apex. The converse, however, does not hold true. Of the eleven species possessing two initials, four have a two-rowed periblem, easily accounted for, however, by the various methods of division of the common initial, or by the early bipartition of the periblem itself.

Digitized by Google

The occurrence of two types of apical structure in different species of the same genus, *Silene*, and in different individuals of the same species, *Portulaca oleracea*, may possibly throw some light upon the numerous discrepancies between Hanstein's observations and those of Douliot. This fact serves to show at least that, while apical structure characterized by a single terminal cell is radically and significantly different from that possessing a number of initials, the two forms of the latter are merely different degrees of the one fundamental structure. The apex growing by the segmentation of two histogens is primitive, and that with three initials is merely a derivative, a variation of it.

The conclusions to be deduced from the above results reinforce Douliot's opinions, already quoted, to the effect that lower grades of development are characterized, for the most part, by an apex with two initials, while higher forms are distinguished chiefly by an apex with three initials. Of six examples in the Apetalæ, Douliot found four possessing two initials. Of the nine species of Apetalæ studied in this paper all have two initials in the apical region, while of the remaining five investigated, Dialypetalæ, one has three initials, one either two or three, and three have two initials.

The University of Nebraska.

Readers will notice that the plates are given two numbers, viz: those conforming to the volume, and those relating to this article alone, and the latter (in parentheses) are used in the text.

Digitized by Google

BIBLIOGRAPHY.

BARANETZKI, S.-Epaississement des Parois des Eléments Parenchymateux. Ann. Nat. Sci. VII. 4:135. 1886.

CLOS, D.—Deuxième Mémoire sur la Rhizotaxie. Ann. Nat. Sci. III. 18:321. 1851.

COSTANTIN, J.—Recherches sur la Structure de la Tige des Plantes Aquatiques. Ann. Nat. Sci. VI. 19:287. 1884.

———— Recherches sur l'Influence qu'Excerce le Milieu sur la Structure des Racines. Ann. Nat. Sci. VII. 1:135. 1885.

DODEL, A.—Der Uebergang des Dicotyledonen-Stengels in der Pfahlwurzel. Pring. Jahrb. 8:149. 1872.

DOULIOT, H.—Recherches sur le Périderme. Ann. Nat. Sci. VII. 10:325. 1889.

———— Recherches sur la Croissance Terminale de la Tige des Phanérogames. Ann. Nat. Sci. VII. 11:283. 1890.

FLAHAULT, Ch.—Recherches sur l'Accroissement Terminale de la Racine chez les Phanérogames. Ann. Nat. Sci. VI. 6:5. 1878.

FLOT, L.—Recherches sur la Zone Périmèdullaire de la Tige. Ann. Nat. Sci. VII. 18:38. 1893.

GERARD, R.—Recherches sur le Passage de la Racine a la Tige. Ann. Nat. Sci. VI. 11:279. 1881.

HERAIL, J.—Recherches sur l'Anatomie Comparée de la Tige des Dicotylédones. Ann. Nat. Sci. VII. 2:208. 1885.

HOULBERT, C.—Recherches sur la Structure Comparée du Bois Secondaire dans les Apétales. Ann. Nat. Sci. VII. 17:1. 1893.

JANCZEWSKI, E. DE—Recherches sur l'Accroissement Terminal des Racines dans les Phanérogames. Ann. Nat. Sci. V. 20:162. 1874.

———— Recherches sur le Développement des Radicelles dans les Phanérogames. Ann. Nat. Sci. V. 20:209. 1874.

LAMOUNETTE, M.—Recherches sur l'Origine Morphologique du Liber Interne. Ann. Nat. Sci. VII. 11:193. 1890.

LECOMTE, H.—Contributions a l'Etude du Liber des Angiospermes. Ann. Nat. Sci. VII. 10:193. 1889.

LEMAIRE, A.- Recherches sur l'Origine et le Développement des Racines Laterales chez les Dicotylédones. Ann. Nat. Sci. VII. 3:163. 1886.

MOROT, L.—Recherches sur le Péricycle du Couche Périphérique du Cylinder Central chez les Phanérogames. Ann. Nat. Sci. VI. 20:217. 1885.

OLIVIER, L.—Recherches sur l'Appareil Tégumentaire des Racines. Ann. Nat. Sci. VI. 11:219. 1881.

PETIT, L.—La Pétiole des Dicotylédones. Ann. Nat. Sci. VII. 6:342. 1887.

PRUNET, A.—Recherches sur les Nœuds et les Entrenœuds de la Tige des Dicotylédones. Ann. Nat. Sci. VII. 13:374. 1891.

RAUWENHOFF, N. W. P.—Observations sur les Caractères et la Formation du Liége dans les Dicotylédones. Ann. Nat. Sci. IV. 12:347. 1829.

SCOTT, D. H.—On Some Recent Progress in Our Knowledge of the Anatomy of Plants. Ann. Bot. 4:147. 1889.

Digitized by Google

SCOTT, D. H. AND BREBNER, G.—On Internal Phloem in the Root and Stem of Dicotyledons. Ann. Bot. 5:259. 1890-91.

VAN TIEGHEM, PH.—Recherches sur la Symétrie de Structure des Plantes Vasculaires. Ann. Nat. Sci. V. 13:5. 1870-71.

———————— Recherches sur la Disposition des Radicelles et des Bourgeons dans les Racines des Phanérogames. Ann. Nat. Sci. VII. 5:180. 1887.

———————— Sur la Réseau de Soutien de l'Ecorce de la Racine. Ann. Nat. Sci. VII. 7:375. 1888.

VAN TIEGHEM, PH. AND DOULIOT, H.—Sur la Polystélie. Ann. Nat. Sci. VII. 3:275. 1886.

———————— Recherches Comparatives sur l'Origine des Membres Endogénes dans les Plantes Vasculaires. Ann. Nat. Sci. VII. 8:1. 1888.

VESQUE, J.—Memoire sur l'Anatomie Comparée de l'Ecorce. Ann. Nat. Sci. VI. 2:82. 1875.

Digitized by Google

EXPLANATION OF PLATES.

THE TRANSITION FROM ROOT TO STEM.

Abbreviations: Ep, epiderm; en, endoderm; ex, exoderm; pr, pericycle; cc, central cylinder; cc′, cortical cylinder; xs, xylem strand; ps, phloem strand; fs, fibrovascular strand; me, mesenchym; c, cambium; px, protoxylem; pp, protophloem; pt, prototracheids; mm, meristem; mx, metaxylem; mp, metaphloem; pc, cortical parenchyma; fc, fibrovascular strands of cotyledons; fn, fibrovascular strands of the first internode; ps′, secondary phloem strands; xs′, secondary xylem strands; me′, medulla.

PLATE VIII (I).—*Dianthus sinensis.*

Fig. 1. Transection of the root just below the collet, showing the typical centripetal, or radial arrangement of the diarch bundle. x 660.

Fig. 2. Transection of the "tigelle" about 1 mm. above the latter: the number of the xylem elements has increased, and the prototracheids have withdrawn from the pericycle. x 880.

Fig. 3. Transection of the "tigelle" a short distance above the latter: the lateral penetration of the xylem strand by the mesenchym has begun, as also the modification of the latter into cambium. x 880.

Fig. 4. Transection of the "tigelle" in the vicinity of the cotyledons: the complete segregation of the xylem strands, and the phloem strands has been effected. x 880.

Fig. 5. Transection of the "tigelle" at the insertion of the cotyledons: the partial superposition of xylem and phloem has occurred, resulting in secantial disposition. x 350.

Fig. 6. Transection of the first internode immediately above the cotyledons: the fibrovascular system of the stem is represented by the stelar circle, composed almost entirely of procambium, except at fs, where the bundle-trace of the next pair of leaves is already somewhat differentiated. x 350.

Fig. 7. Epiderm and exoderm of the "tigelle" in transection. x 350.

Fig. 8. Epiderm and exoderm of the root in transection. x 350.

PLATE IX (II).—*Silene armeria.*

Fig. 1. Transection of the root in the region of the collet: the duplication of the xylem strand has already occurred. x 880.

Fig. 2. Transection of the "tigelle" about 1 mm. below the cotyledons: the intrusion of the mesenchym has just begun. x 460.

Digitized by Google

Fig. 3. Transection of the "tigelle" just beneath the insertion of the cotyledons: the strands of the central cylinder are in secantial orientation. x 460.

Fig. 4. Transection of the young stem: the strands of the first internode, which are destined for the next pair of leaves above, are shown at fn. x 200.

Fig. 5. Epiderm and exoderm of the root in transection. x 800.

Fig. 6. Epiderm and exoderm of the "tigelle" in transection. x 300.

PLATE X (III).—*Silene conoidea.*

Fig. 1. Transection of the root, showing the typical structure of the central cylinder. x 880.

Fig 2. Transection of the upper portion of the root: the duplication of the xylem has begun, but the prototracheids are still in contact with the pericycle. x 880.

Fig. 3. Transection of the lower portion of the "tigelle": the duplication has reached its limit, and the mesenchym has already interposed a single row of cells between prototracheid and pericycle. x 460.

Fig. 4. Transection of the "tigelle" just below the insertion of the cotyledons: the medulla occupies the whole of the centre of the cylinder; the phloem and xylem strands are passing from the secantial to the centrifugal disposition. x 450.

Fig. 5. Transection of the stem just above the cotyledons: at fn are shown the strands destined for the leaves of the first internode; at fn′ the beginnings of the strands for the second internode. x 460.

Fig. 6. Epiderm and exoderm of the root in transection. x 350.

Fig. 7. Epiderm and exoderm of the "tigelle" in transection. x 850.

PLATE XI (IV).—*Silene otites.*

Fig. 1. Transection of the root, showing the typical structure of the central cylinder. x 880.

Fig. 2. Transection of the root near the collet, showing the beginning of the duplication of the xylem elements, and, concomitantly, the withdrawal of the prototracheids from the pericycle. x 880.

Fig. 3. Transection of the "tigelle" about one-half mm. below the cotyledons: the amyliferous endoderm is here especially prominent; the xylem strand is breaking up into secondary strands, while the mesenchym in front of the phloem is being modified to form procambium. x 880.

Fig. 4. Transection of the "tigelle" just below the insertion of the cotyledons: the central pith is well-developed; the bundles are in secantial disposition. x 300.

Fig. 5. Epiderm and exoderm of the root in transection. x 460.

Fig. 6. Epiderm and exoderm of the "tigelle" in transection. x 460.

Digitized by Google

PLATE XII (V).—*Portulaca oleracea.*

Fig. 1. Transection of the root, showing the typical structure of the stele. x 460.

Fig. 2. Transection in the vicinity of the collet; the duplication of the xylem has taken place, likewise the division of the phloem strands. x 460.

Fig. 3. Transection of the "tigelle" about 2 mm. below the cotyledons; the intrusion of the mesenchym has split the xylem into two groups. x 460.

Fig. 4. Transection of the "tigelle" a short distance below the cotyledons: the xylem and phloem strands have united at fc to form the strand of the cotyledons; at c are shown the procambial strands originative of the bundles of the first internode. x 460.

Fig. 5. Transection of the "tigelle" immediately below the insertion of the cotyledons: fc, fibrovascular strands of the cotyledons; fn, fibrovascular strands of the first internode. x 460.

Fig. 6. Epiderm and exoderm of the root in transection. x 460.

Fig. 7. Epiderm and exoderm of the "tigelle" in transection. x 460.

PLATE XIII (VI).—*Allionia hirsuta.*

Fig. 1. Transection of the root, showing the typical structure of the stele. x 400.

Fig. 2. Transection of the root: the "running out" of the central vessels is taking place, and, concomitant with it, the intrusion of the mesenchym. x 400.

Fig. 3. Transection of the root a short distance below the collet; the xylem has separated into four strands, two of which are entirely prototracheidal. x 400.

Fig. 4. Transection of the root a short distance above the latter: the prototracheids are disappearing, each phloem strand has divided to form two secondary strands, and the two remaining xylem strands have each split to form three. x 460.

Fig. 5. Transection of the lower portion of the "tigelle"; the four bundles at fc are destined to form the vascular strands of the cotyledons. x 460.

Fig. 6. Transection of the "tigelle" immediately below the cotyledons; at fn are shown the lower ends of the bundle-traces of the first internode, at tt the residual tracheids of the xylem. x 300.

Digitized by Google

PLATE XIV)VII).—*Allionia nyctaginea.*

Fig. 1. Transection of the root, showing the typical structure of the stele. x 400.

Fig. 2. Transection of the root, showing the disintegration of the central elements of the xylem, and the separation of the latter into two plates. x 400.

Fig. 3. Transection of the root at the beginning of the collet; the pith has made its appearance in the centre of the cylinder, and has further split the xylem into four strands. x 400.

Fig. 4. Transection of the collet, showing the secantial disposition of the xylem and phloem. x 800.

Fig. 5. Transection of the lower portion of the "tigelle", showing the two collateral bundles of the stem; pt, prototracheids; tt, residual tracheids. x 800.

Fig. 6. Epiderm and exoderm of "tigelle" in transection. x 250.

Fig. 7. Epiderm and exoderm of root in transection. x 250.

PLATE XV (VIII).—*Amarantus retroflexus.*

Fig. 1. Transection of the root, showing the type structure of the stele. x 880.

Fig. 2. Transection of the hypocotyl in the region of the "tigelle," showing the beginning of the duplication of the xylem. x 880.

Fig. 3. Transection of the "tigelle" about 1 mm. below the cotyledons in the normal transition, just below the cotyledons in the abrupt transition. The mesenchym has forced the secondary xylem strands between the secondary phloem plates. x 460.

Fig. 4. Transection of the "tigelle" immediately below the cotyledons: the bundles at fc are in secantial orientation, those at fn are perfectly collateral. x 400.

Fig. 5. Transection of the "tigelle" at the insertion of the cotyledons: the vascular strands at fc are passing over to the collateral orientation; those at fn are splitting to form the stelar system of the node next above. x 350.

Fig. 6. Epiderm and exoderm of "tigelle" in transection. x 460.

Fig. 7. Epiderm and exoderm of root in transection.

PLATE XVI (IX).—*Beta alba.*

Fig. 1. Transection of the root, showing the typical disposition of elements in the central cylinder. x 880.

Fig. 2. Transection of the collet, showing duplication of the xylem strand. x 880.

Digitized by Google

Fig. 3. Transection of the "tigelle" near the middle: the splitting of the xylem plate has already begun, as also the transformation of the mesenchym into procambium. x 460.

Fig. 4. Transection of the "tigelle" just below the cotyledons; the xylem has split transversely into two strands, likewise one of the phloem plates.

Fig. 5. Epiderm and exoderm of root in transection. x 880.

Fig. 6. Epiderm and exoderm of "tigelle" in transection. x 880.

PLATE XVII (X).—*Chenopodium album.*

Fig. 1. Transection of the root, showing the type structure of the stele. x 880.

Fig. 2. Transection of the lower portion of the "tigelle", showing the duplication of the xylem. x 880.

Fig. 3. Transection of the "tigelle" about 2 mm. below the cotyledons: the medulla, occupies the centre of the cylinder, the xylem and phloem assuming secantial disposition; at fn, a primary vascular strand of the first internode has already been cut off. x 460.

Fig. 4. Transection of the "tigelle" immediately below the cotyledons; the four cotyledonary strands have coalesced into two, and all the strands have passed into the collateral arrangement. x 660.

Fig. 5. Epiderm and exoderm of "tigelle" in transection. x 880.

Fig. 6. Epiderm and exoderm of root in transection. x 880.

PLATE XVIII (XI).—*Phytolacca decandra.*

Fig. 1. Transection of the upper part of the root, showing the beginning of duplication. x 350.

Fig. 2. Transection of the "tigelle" near the middle; the medulla has separated the xylem into transverse plates. x 350.

Fig. 3. Transection of the "tigelle" about one-half mm. below the cotyledons; the vascular elements are assuming secantial orientation. x 300.

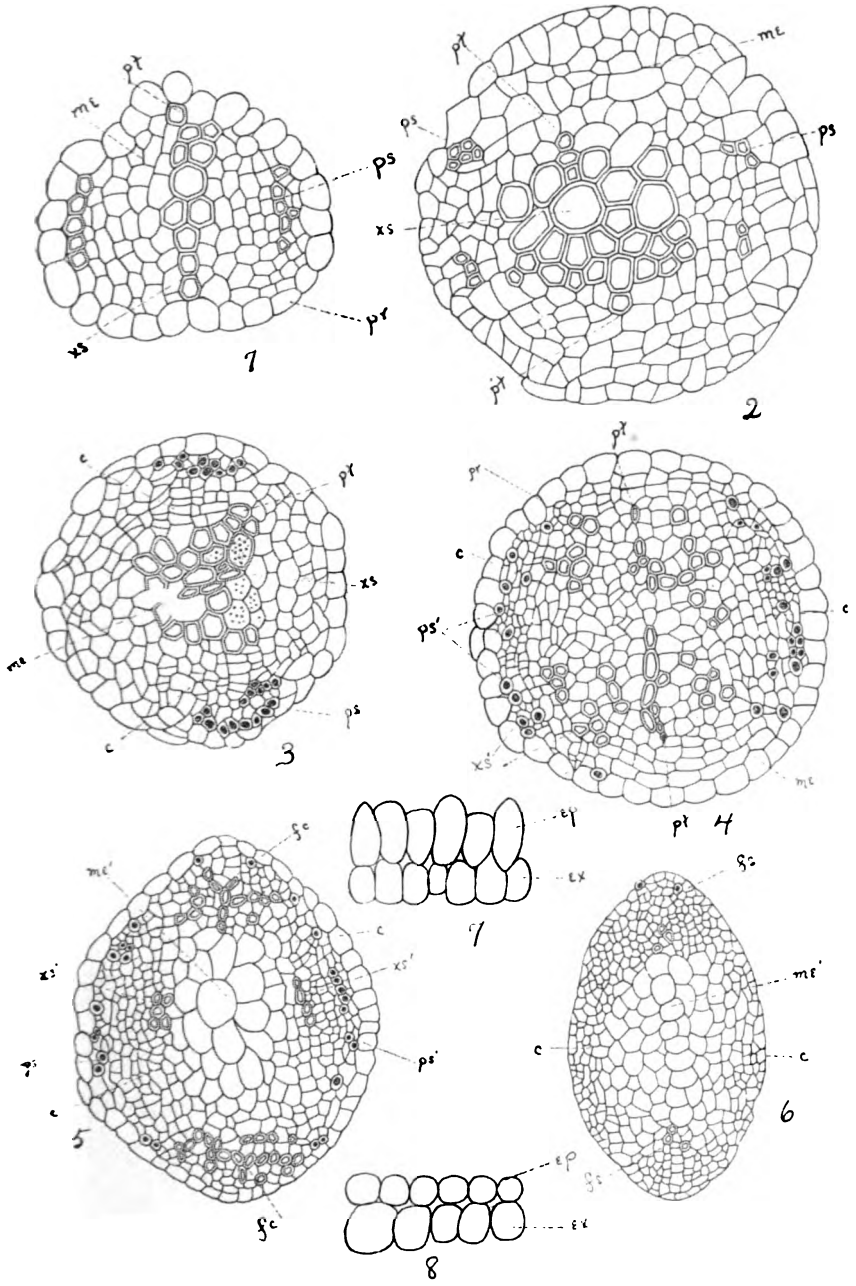
Fig. 4. Transection of the "tigelle" immediately below the insertion of the cotyledons; the disposition of elements is nearly intermediate between secantial and collateral disposition. x 300.

Fig. 5. Epiderm and exoderm of root in transection. x 460.

Fig. 6. Epiderm and exoderm of "tigelle" in transection. x 460.

Digitized by Google

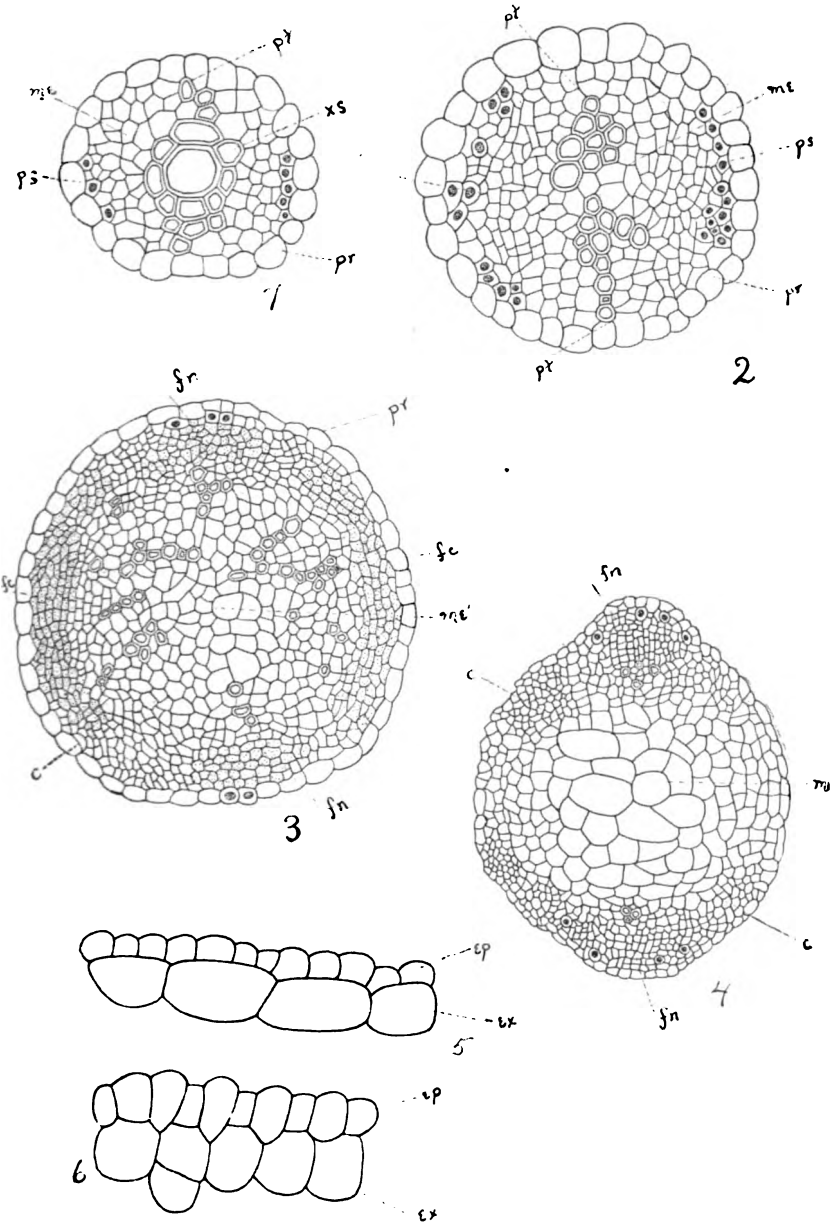
PLATE VIII



Digitized by Google

Digitized by Google

PLATE IX

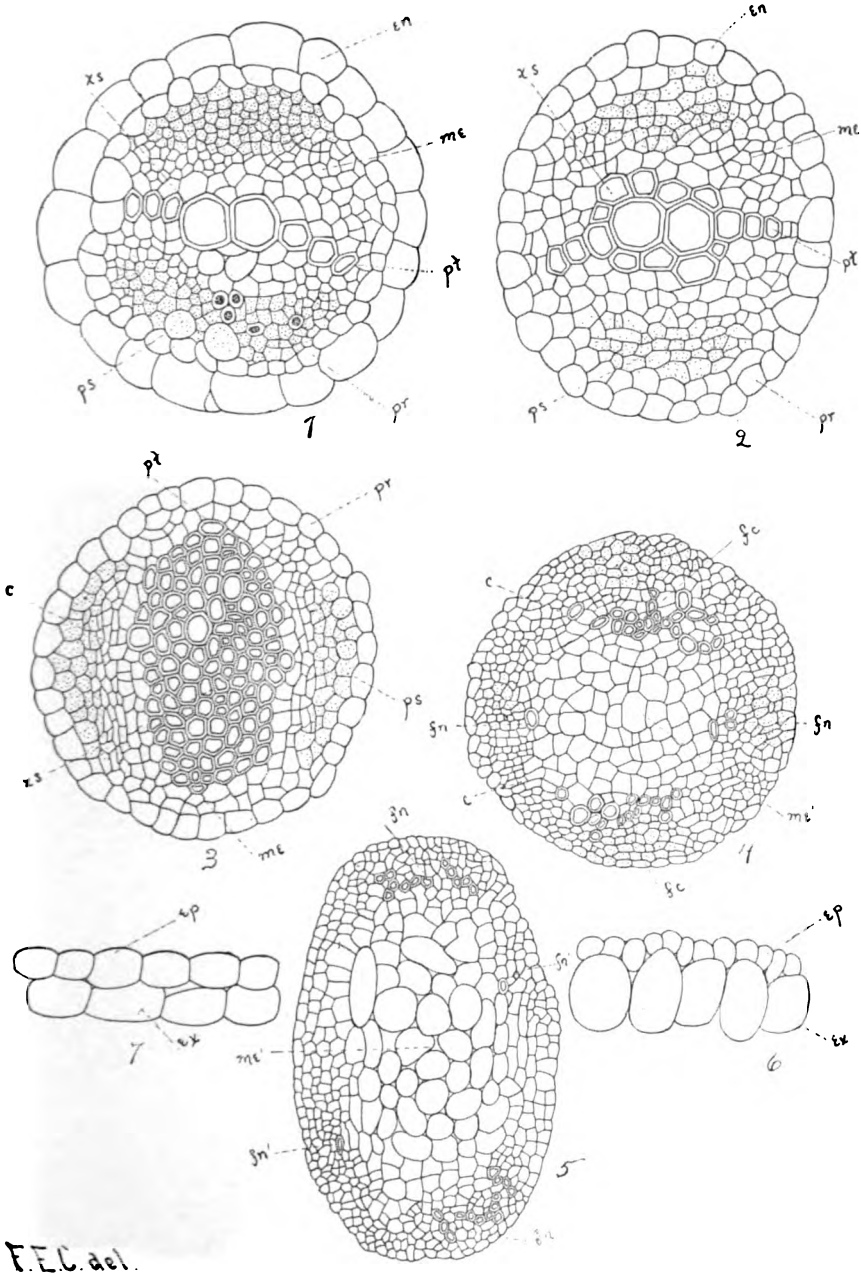


F.E.C del.

Digitized by Google

Digitized by Google

PLATE X

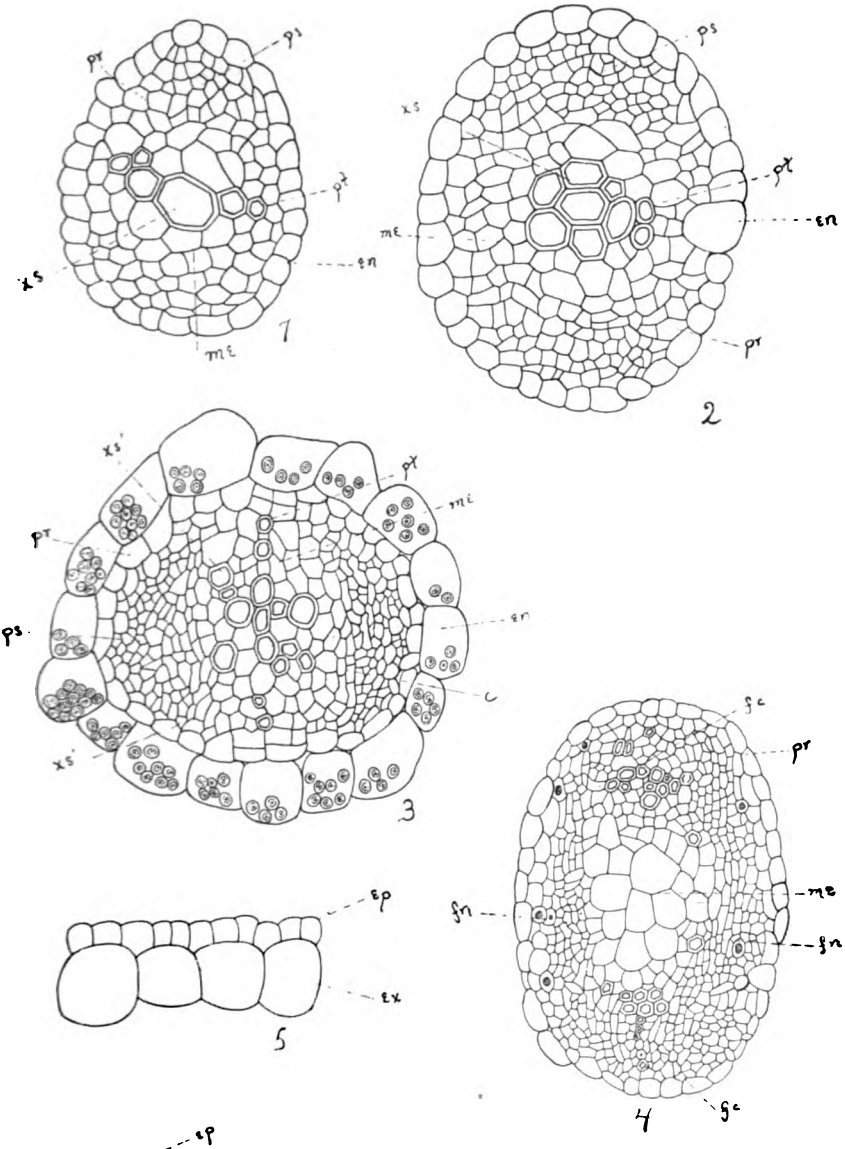


F.E.C. del.

Digitized by Google

Digitized by Google

PLATE XI

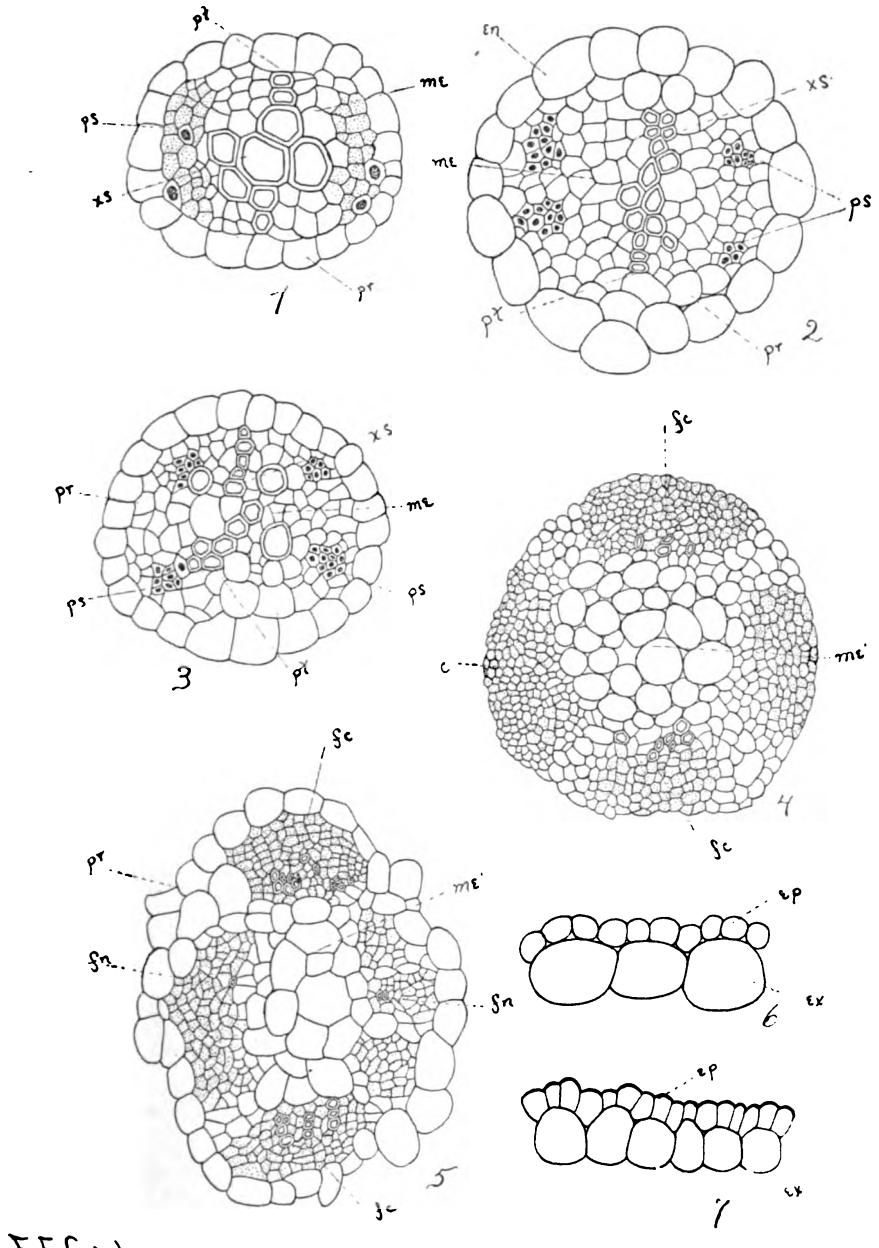


F.E.C. del.

Digitized by Google

Digitized by Google

PLATE XII

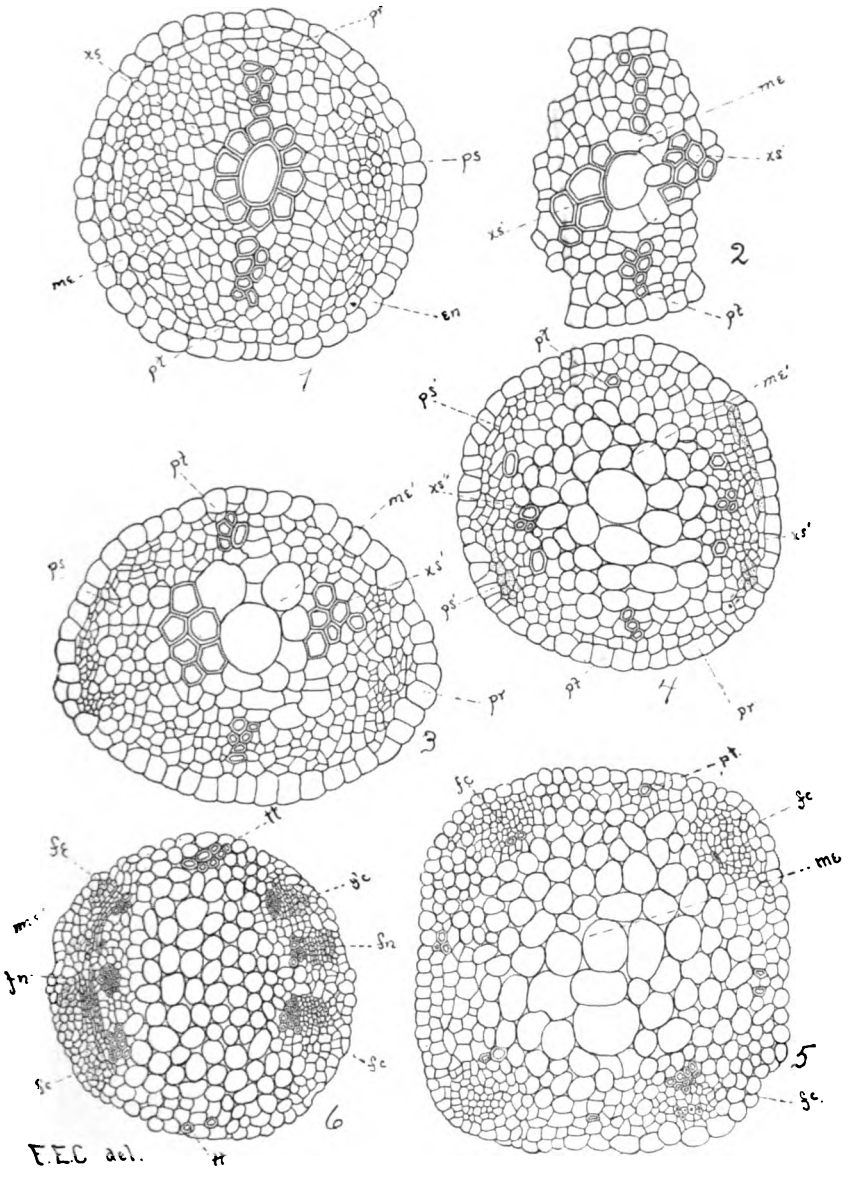


F.E.C. del.

Digitized by Google

Digitized by Google

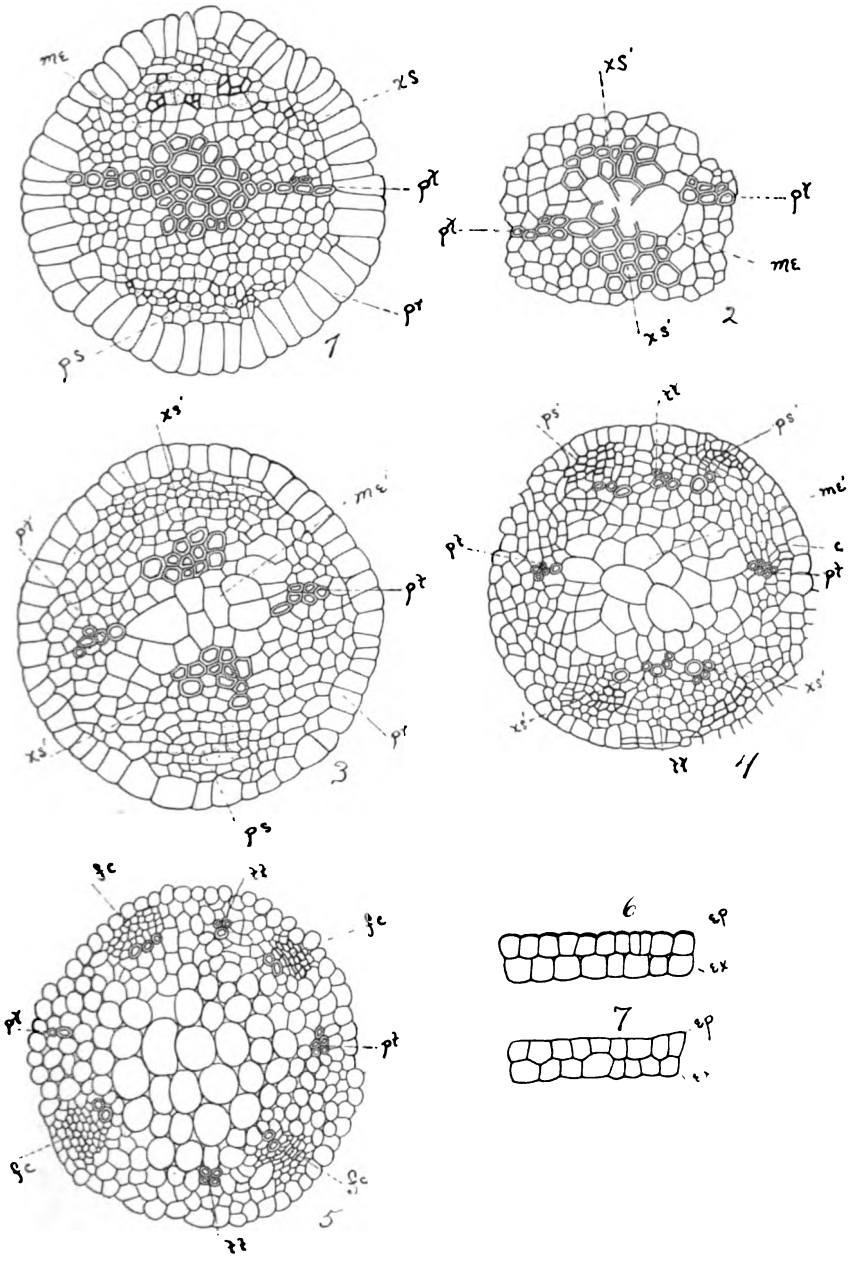
PLATE XIII



Digitized by Google

Digitized by Google

PLATE XIV

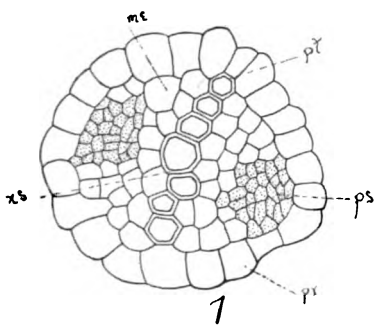


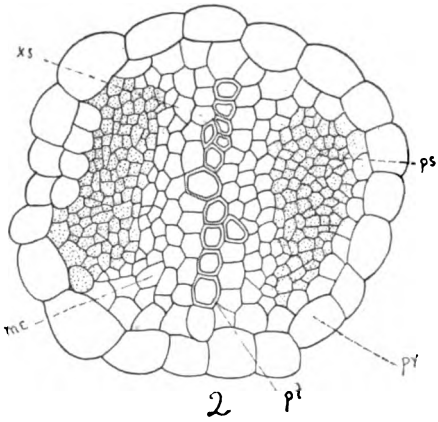
F.E.C. del.

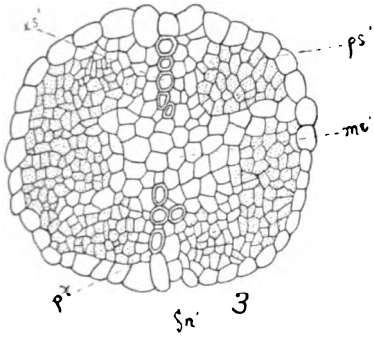
Digitized by Google

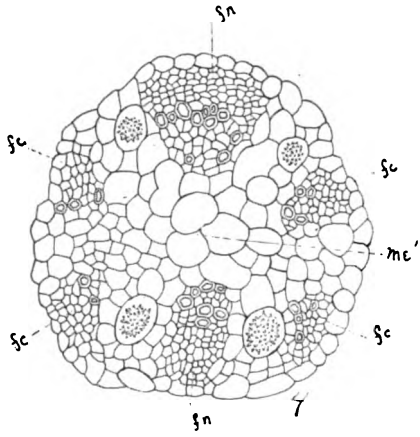
Digitized by Google

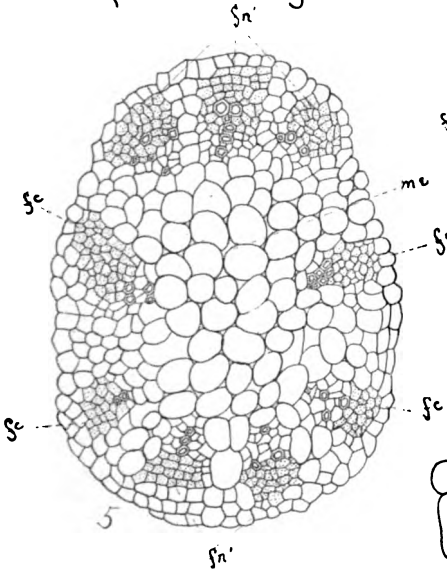
PLATE XV

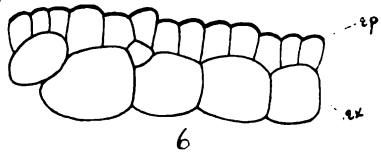


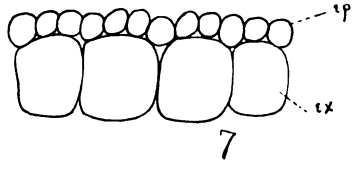










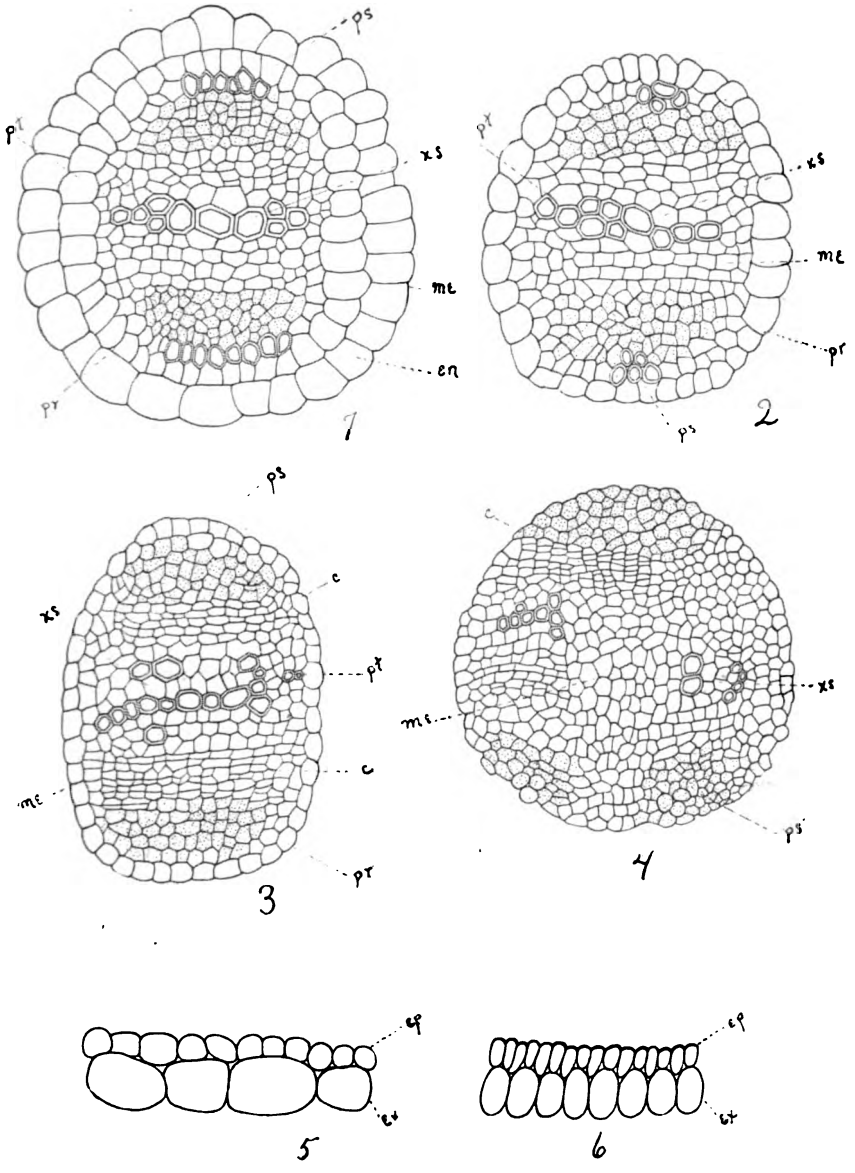


F.E.C. del

Digitized by Google

Digitized by Google

PLATE XVI

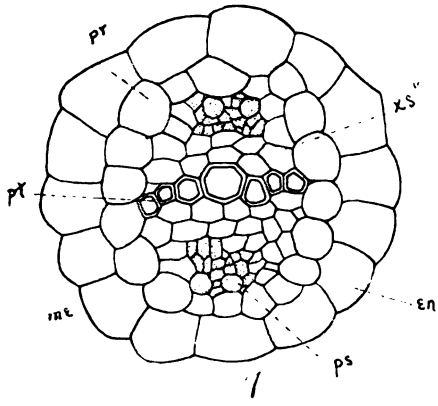


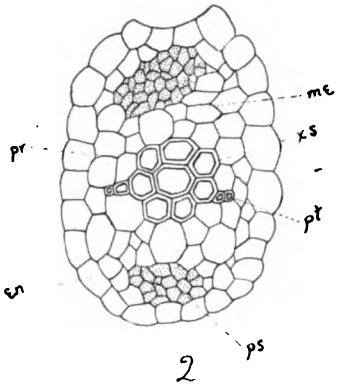
T.E.C. del.

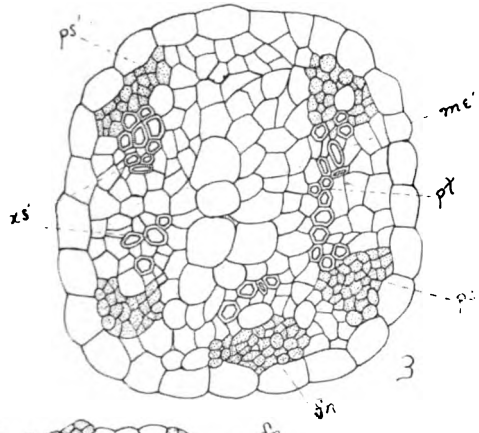
Digitized by Google

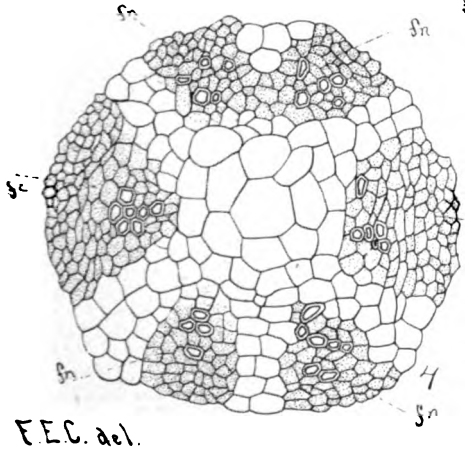
Digitized by Google

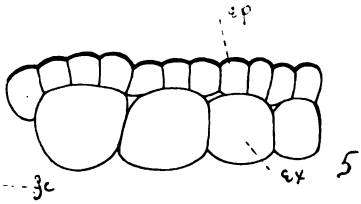
PLATE XVII

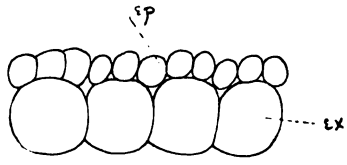










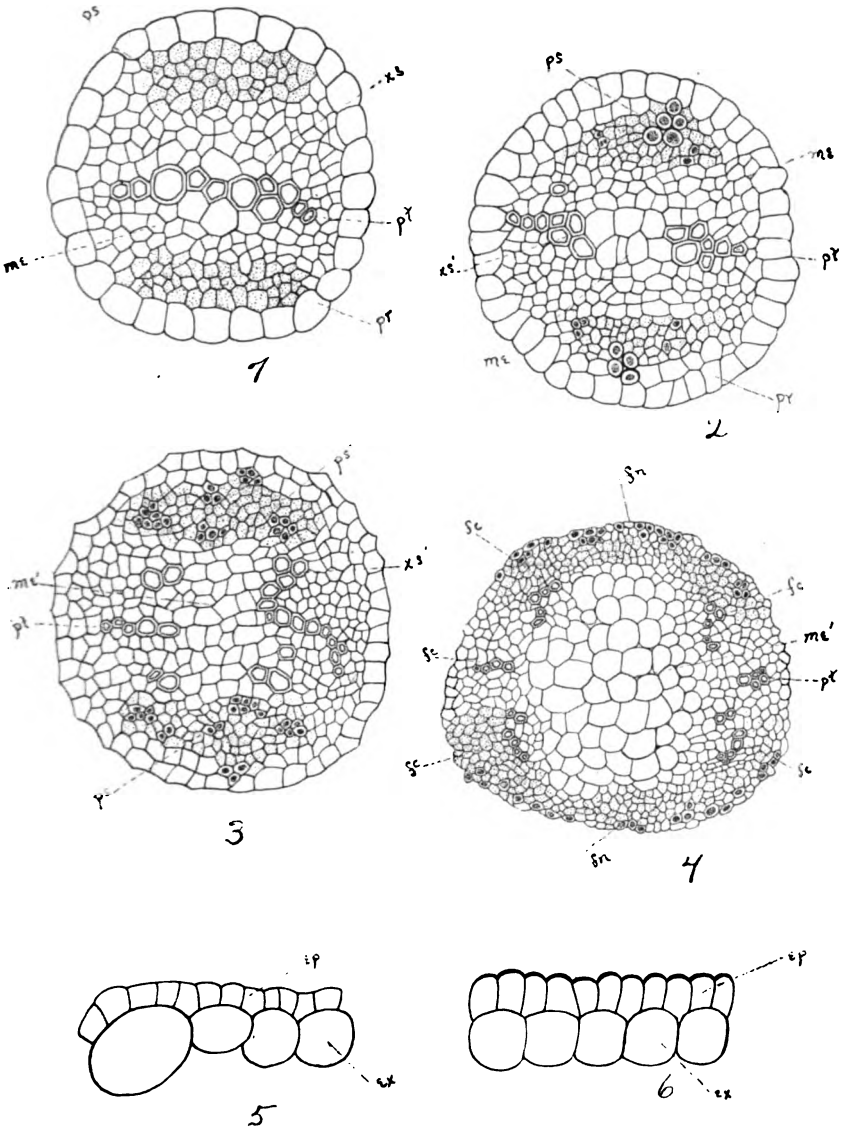


F.E.C. del.

Digitized by Google

Digitized by Google

PLATE XVIII

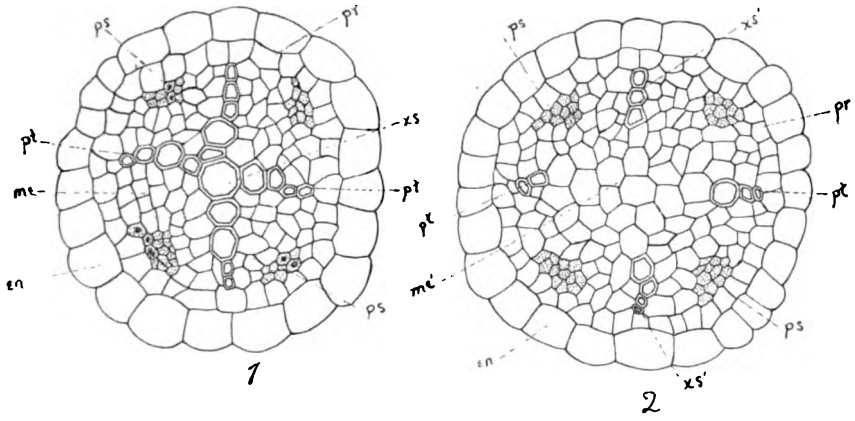


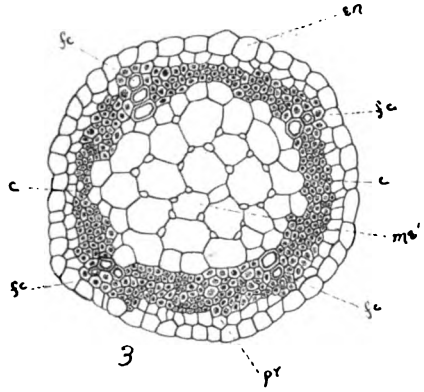
F.E.C. del

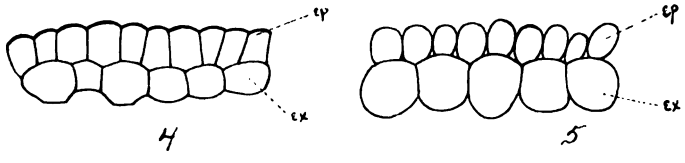
Digitized by Google

Digitized by Google

PLATE XIX





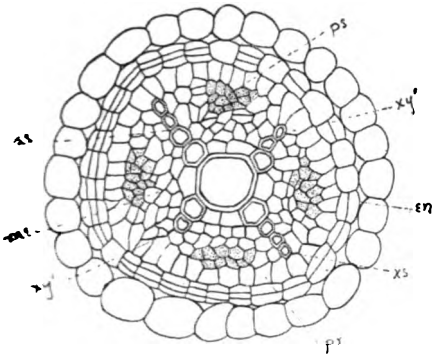


F.E.C. del.

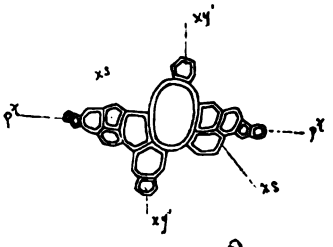
Digitized by Google

Digitized by Google

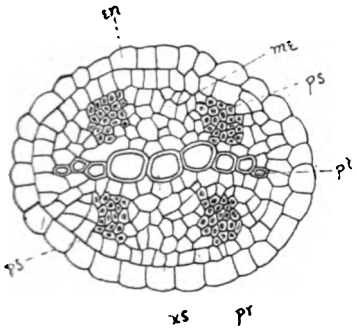
PLATE XX



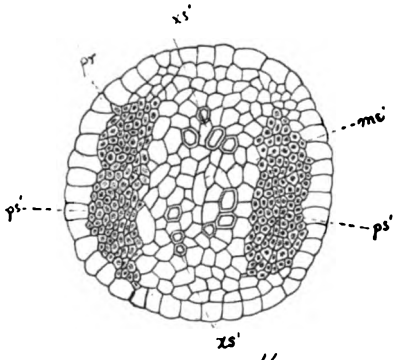
1



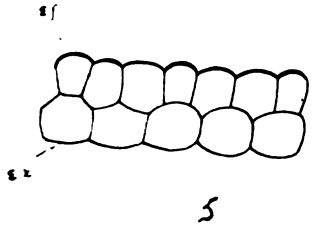
2



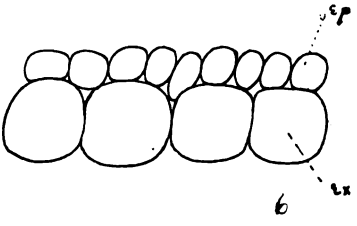
3



4



5



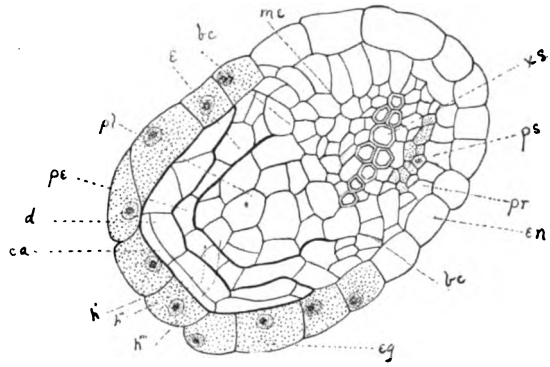
6

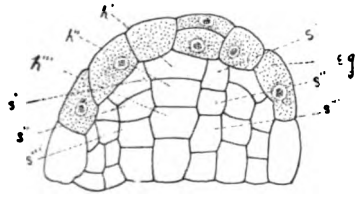
F E C. del

Digitized by Google

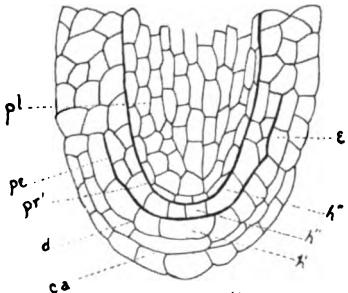
Digitized by Google

PLATE XXI

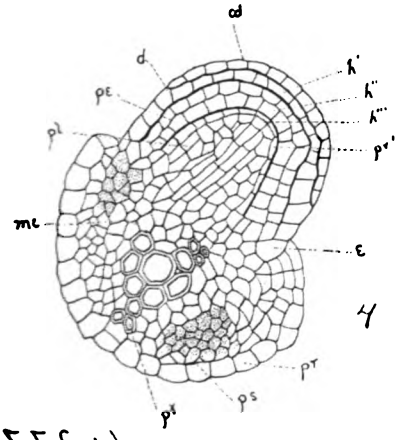




2



3



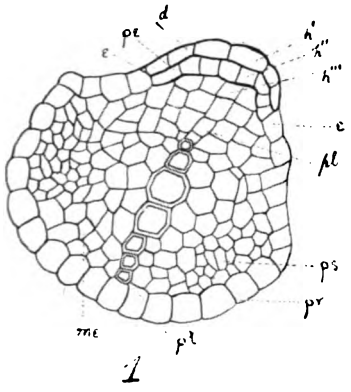
4

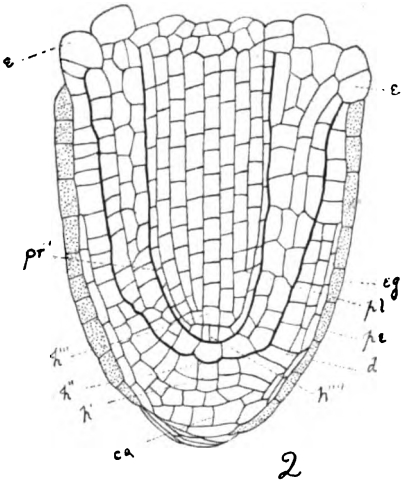
F.E.C. del

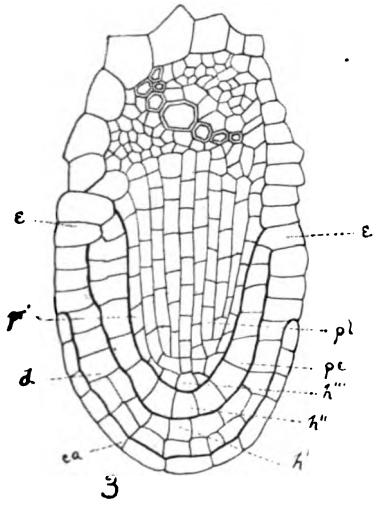
Digitized by Google

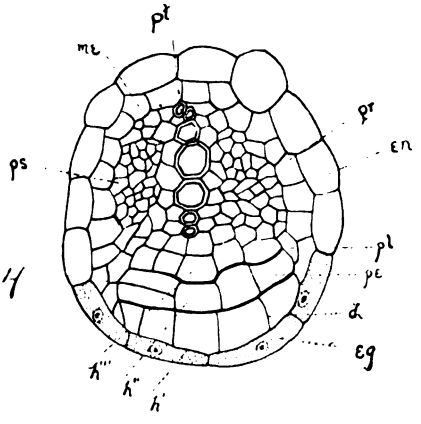
Digitized by Google

PLATE XXII







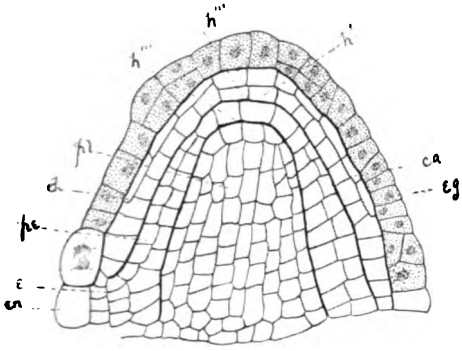


F.E.C. del.

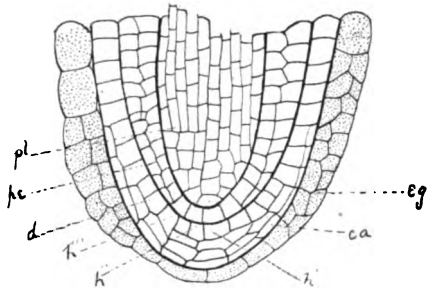
Digitized by Google

Digitized by Google

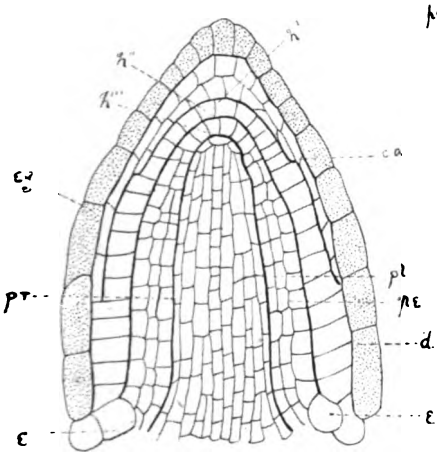
PLATE XXIII



1



2



3

E.E.C del

Digitized by Google

Digitized by Google

PLATE XIX (XII).—*Polygonum lapathifolium.*

Fig. 1. Transection of the upper part of the root, showing type structure of the stele. x 350.

Fig. 2. Transection of the "tigelle" near the middle; the medulla has appeared in the centre and has separated the four rays of the xylem into as many secondary strands. x 350.

Fig. 3. Transection of the "tigelle" about one-fourth mm. below the cotyledons: the phloem elements form a continuous circle, in the quadrants of which are situated the centripetal xylem-phloem strands, fc; at c is shown the interfascicular procambium which originates the first internodal stele. x 350.

Fig. 4. Epiderm and exoderm of "tigelle" in transection. x 460.

Fig. 5. Epiderm and exoderm of root in transection. x 460.

PLATE XX (XIII).—*Rumex altissimus.*

Fig. 1. Transection of the root, showing type structure of the stele: xs, primary rays of the xylem; xy′, secondary rays. x 460.

Fig. 2. Xylem plate from the lower portion of the "tigelle", showing the duplication of the primary rays, and the disappearance of the secondary ones. x 460.

Fig. 3. Transection through the middle of the "tigelle"; the xylem has become uniseriate, and has assumed a pseudo-diarch character. x 460.

Fig. 4. Transection of the "tigelle" just below the cotyledons; the xylem plate has split into two, while the phloem strands have coalesced to form but two. x 460.

Fig. 5. Epiderm and exoderm of "tigelle" in transection. x 460.

Fig. 6. Epiderm and exoderm of root in transection. x 460.

Digitized by Google

THE ORIGIN AND DEVELOPMENT OF RADICELS.

Abbreviations: Ep, epiderm; ex, exoderm; cc′, cortical cylinder; cc, central cylinder; en, endoderm; pr, pericycle; xs, xylem strand; ps, phloem strand; fs, fibrovascular strand; me, mesenchym; e, epistele: d, dermatogen; pe, periblem; pl, plerome; c, cambium; pt, prototracheids; mx, metaxylem; px, protoxylem; mp, metaphloem; pp, protophloem; g, digested cells of the cortical cylinder; h′, histogen of the dermatogen; h″, histogen of the periblem; h‴, histogen of the plerome; h⁗, histogen of the pericycle of the plerome; ca, calyptrogen; eg, epigen; bc, basal cells of the radicel; pr′, pericycle of radicel; s′, s″, s‴, segments respectively of histogen of dermatogen, periblem and plerome.

PLATE XXI (XIV).

Fig. 1. Transection of the root of a seedling, *Dianthus sinensis*, passing through the axis of a radicel. The three zones have become well-differentiated, and the calyptrogen has been set off as a layer of five cells. The histogen of each zone is apparently single; they are, however, not serial. The epigen still consists of its original ten cells, half the number of those in the endoderm. They are very sharply set off, however, from the remaining ten cells by reason of their large nuclei and dense protoplasm. x 350.

Fig. 2. Transection of the same. The histogens of the three zones are superimposed. Their segments are extremely irregular, and the delimitation between the three zones is as yet not very evident. The epigen is composed of but six cells; the central one presents transverse division, anomalous for this species. x 660.

Fig. 3. Transection of an older radicel of the same. The radicel has penetrated the entire cortical cylinder of the root and has finally absorbed the epigen. It is still protected at the tip, however, by the two calyptral layers cut off from the dermatogen. The pericycle of the plerome is now first differentiated. x 660.

Fig. 4. Transection of the root of *Silene otites*, showing the radicel in longitudinal axial section. The epigen is lacking and the calyptrogen lies directly against the tissue of the cortical cylinder. The periblem has already divided itself into two layers, originative of the endoderm and exoderm.

Digitized by Google

PLATE XXII (XV).

Fig. 1. Transection of the root of *Portulaca oleracea*, showing the young root in longitudinal section. No epigen is developed, and the dermatogen lies directly against the endoderm at this time. x 460.

Fig. 2. Transection of the root of *Allionia hirsuta*, showing the radicel in longitudinal axial section at the time when it has broken through the cortical cylinder. The terminal cells of the epigen are already dissolved, and exfoliation has begun in the calyptra. x 460.

Fig. 3. Transection of the root of *Amarantus albus*, showing the radicel in longitudinal section at the time of the absorption of the endoderm. The epigen is lacking, and the cells of the calyptrogen lie directly against the cortical cylinder. x 460.

Fig. 4. Transection of the root of *Chenopodium album*, showing the very young radicel in longitudinal section. The three layers derived from the division of the pericycle are very distinct. The tip of the developing radicel is covered with four cells of the endoderm modified to form an epigen. x 460.

PLATE XXIII (XVI).

Fig. 1. Transection of the root of *Beta alba*, showing the radicel in longitudinal axial section. Nearly the entire endoderm covering the radicel has been changed into epigen; near the base this process is still going on. The first layer of the calyptra has already been cut off. x 460.

Fig. 2. Transection of the root of *Phytolacca decandra*, showing a longitudinal section of the radicel. The two-layered epigen has already begun to be absorbed at the apex. x 460.

Fig. 3. Transection of the root of *Rumex altissimus*, showing longitudinal section of a radicel just ready to leave the root. The epigen still persists at the apex of the radicel. Beneath it, the calyptra has already obtained a thickness of three layers. x 460.

Digitized by Google

THE APICAL GROWTH OF THE STEM.

Abbreviations: pl, plerome cylinder; pe, periblem; d, dermatogen; h′, initial of the dermatogen; h″, initial of the periblem, or common initial of the periblem and plerome; h‴, initial of the plerome. All figures are magnified 460 diameters.

PLATE XXIV (XVII).

Fig. 1. Longisection of the apex of a seedling, *Dianthus sinensis*.

Fig. 2. Longisection of apex of seedling, *Silene armeria*.

Fig. 3. Longisection of apex of seedling, *Silene otites*.

Fig. 4. Longisection of apex of seedling, *Portulaca oleracea*.

Fig. 5. Longisection of apex of a branch of *Portulaca oleracea*.

Fig. 6. Longisection of apex of seedling, *Allionia hirsuta*.

Fig. 7. Longisection of apex of seedling, *Allionia nyctaginea*.

PLATE XXV (XVIII.)

Fig. 1. Longisection of apex of seedling, *Amarantus albus*.

Fig. 2. Longisection of apex of seedling, *Amarantus retroflexus*.

Fig. 3. Longisection of apex of a branch of *Chenopodium album*.

Fig. 4. Longisection of apex of seedling. *Beta alba*.

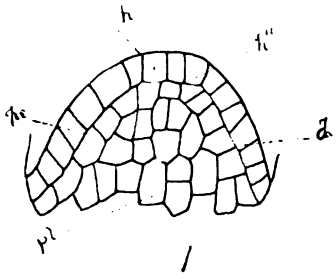
Fig. 5. Longisection of a flower-bud of *Phytolacca decandra*.

Fig. 6. Longisection of apex of seedling, *Polygonum lapathifolium*.

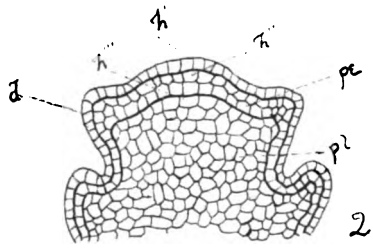
Fig. 7. Longisection of apex of seedling, *Rumex altissimus*.

Digitized by Google

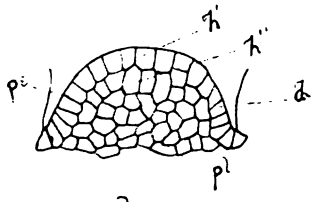
PLATE XXIV



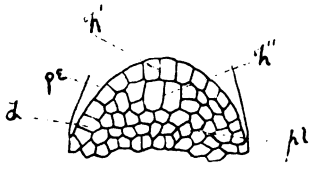
1



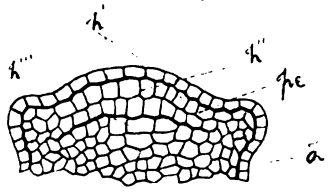
2



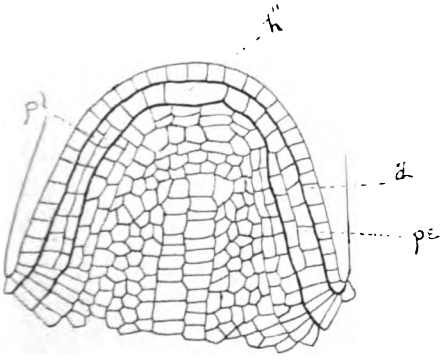
3



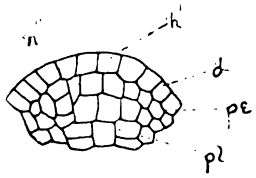
4



5



6



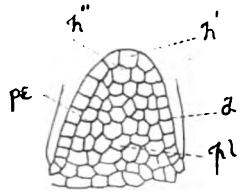
7

F.E.C. del.

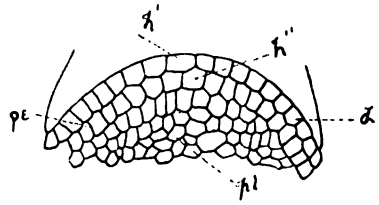
Digitized by Google

Digitized by Google

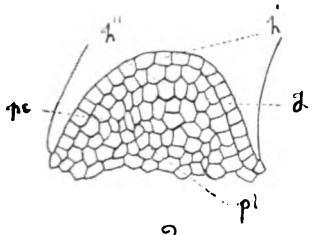
PLATE XXV



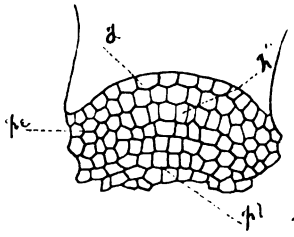
1



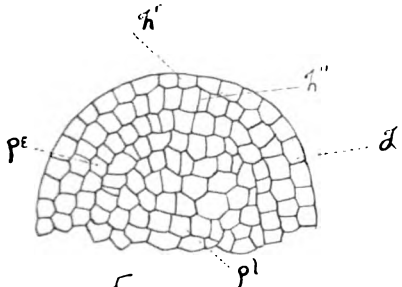
2



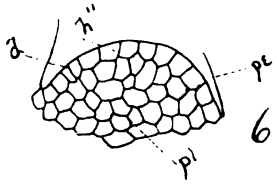
3



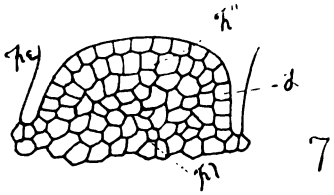
4



5



6



7

F.E.C. del.

Digitized by Google

Digitized by Google

CARCINOMA ON THE FLOOR OF THE PELVIS.

TWO DISCOVERIES IN CANCEROUS DISEASE.

MARY A. DIXON JONES, M. D., NEW YORK CITY.

A woman nearly fifty years of age called to see me February 18, 1888; said she had been treated for many years by various physicians, but without relief; that she was growing steadily worse, and that at times her sufferings were most intense.

I found the uterus drawn to the extreme right, and with the corresponding tube and ovary, fixed by inflammatory adhesions. The left uterine appendages were prolapsed and adherent to a mass the size of a small orange, in the centre of the pelvic floor. This mass or tumor was soft, extremely sensitive, and with some apparent fluctuation. Her last physician, diagnosing it to be a misplaced uterus, had from time to time made various and continued efforts to put the supposed organ in position. These manipulations gave the patient great distress, the pain often lasting several days. I advised the immediate removal of the tumor as her only chance of recovery. Her husband was anxious that the operation should be performed, but wished it to be done in his own home. I refused to perform such an operation unless every circumstance, as far as I could judge, was the most favorable for the patient's recovery, and suggested that she enter the hospital. Dr. E. A. Wheeler, who had advised the patient to consult me, also thought it best. She entered the Woman's Hospital of Brooklyn, March 16, 1888. So much had she suffered that she said to me the day before the operation: "If you were to tell me that I had but one chance in twenty-five, I would take that chance and have the operation".

Digitized by Google

The operation was performed on March 19, 1888. I removed first the left tube and ovary with the tumor to which they were adherent. All had grown so firmly to the floor of the pelvis that the separation was attended with great difficulty and followed by severe hemorrhage, which was almost uncontrollable. Nothing checked it but securely clamping the torn edges of the wound, and for this I used forceps whose handles projected beyond the abdominal incision. I had previously removed considerable portion of what I supposed to be affected tissue. The pseudo-membranous adhesions which bound the uterus and right uterine appendages were separated and the latter removed. The peritoneal cavity was thoroughly flushed with water sterilized by heat; a drainage-tube was introduced, and for still more thorough drainage a large strip of gauze was inserted in the abdominal wound, extending beneath the line of sutures down to the floor of the pelvis. The abdominal wound was dressed, the patient placed comfortably in bed, and in every respect, she seemed to be doing well. Still there were indications that the disease was malignant and I had little hope of her recovery. Statistics show that operations for malignant disease of the abdomen are almost invariably fatal.[1]

The patient came comfortably out of ether. In two hours the drainage tube was drawn off, the dressings were found fully saturated with bloody serum, and new dressings were applied. So for several days three or four times in the twenty-four hours the wound was redressed, and in twenty hours the forceps and gauze were removed. She continued to improve, and in five weeks was able to leave the hospital. She did so well that I dismissed the idea of the disease being malignant, and it was

1. In 1881, in St. Luke's Hospital, "2 cases of malignant tumor of the abdomen, 2 deaths". In New York State Women's Hospital, in 1887, "2 cases of carcinoma of omentum, exploratory incision, death"; "carcinoma of ovary, ovariotomy, death". In 1886, 3 carcinomata of omentum, exploratory incision, all died; Sarcoma, exploratory incision, death. In 1887, 2 cases of carcinomata of omentum, both died of shock, after exploratory incision; carcinoma ovarii, ovariotomy, death; sarcoma ovarii, ovariotomy, death. In 1886, cancer of the ovaries, exploratory incision, death.

Digitized by Google

not until the eighth day of the following December, nine months after the operation, when in due course, I studied microscopically the specimen and found it was a cancer, and portions of it were of a most malignant type. The left tube and ovary were both found infiltrated with cancerous growth. The right tube also showed inflammatory reaction, and gave indications that the cancer was rapidly spreading.

The same day I discovered this condition, I sent for the husband, and Dr. Wheeler. I informed the former of his wife's condition, and that in the natural course of the disease the patient could not live more than a few months. Dr. Wheeler said, and afterward wrote: "There was no doubt the operation had greatly prolonged the patient's life, and relieved in a great measure her sufferings". Still it was evident the malignant degeneration had been existing only about one year; and if the growth had been removed at an earlier period, or before it had infiltrated surrounding structures, the disease might have been entirely eradicated, and the patient saved.

Cancer is primarily a local disease induced by local irritation. In this instance the disease was clearly of local origin. The patient had been sick since the birth of her last child, then thirteen years of age. At that time there was some sepsis, which resulted in pelvic peritonitis, salpingitis, and oophoritis, followed by the displacement of the Fallopian tubes and ovaries, and the formation of pseudo-membranous adhesions, Repeated attacks of peritonitis increased the disease, and the long continued local irritation developed the cancer, which finally ended her existence[1].

If the uterine appendages in this patient had been removed eight or ten years previously, the source of irritation would have been removed, and the development of cancer, in all probability, prevented. At that time, too, the necessary surgical interference would have been comparatively simple.

The case of this pelvic tumor had been one of exceeding interest to me, and from time to time, I returned to the study of

1. She died thirteen months after the operation, a large secondary growth in the peritoneal cavity.

Digitized by Google

it; but repeated and careful microscopical examinations, not only left unsettled the question as to the cause of the disease, but even as to where the cancer started. According to modern views, first announced by Thiersch and Waldeyer, a normal epithelial structure is required for giving rise to the cancer. There is no structure on the floor of the pelvis, unless we resort to the hypothesis, that a parovary was the initial source of the grown cancer. A sufficient number of cases is, however, on record, where cancer has started in pure connective tissue formations, entirely devoid of epithelial structure.

The tumor, with the adjacent tissues, was placed in a dilute solution of chromic acid, until thoroughly hardened, and afterward sliced for the microscopical research. The main tumor exhibits three varieties of cancer, i. e., scirrhous, adenoid, and medullary cancer.

The scirrhous portion appear to be composed of an extremely firm and dense fibrous connective tissue, with scanty nests of epithelia dispersed in it. It is mainly in the cross sections that we meet with epithelial nests. In many places, the protoplasmic bodies, between the bundles, the so-called connective tissue cells are enlarged, or found in a state of active proliferation by a more or less pronounced outgrowth of living matter. In such places the splitting up of the protoplasmic bodies into rows and chains of nucleated, coarsely granular bodies is plainly seen. Even in the scirrhous portion, we not unfrequently meet with nests hollowed out in their centre thereby showing a tendency to change into the adenoid variety. The epithelia of the nests are small, provided with distinct nuclei and nucleoli, and separated from one another by a light rim of cement substance traversed by delicate thread-like formations.

Close by we meet with a variety termed "adenoid" or gland like. This form is conspicuous by epithelial nests hollowed out in their centre into more or less regular cavities, typical of all glandular tissue. With high powers we can ascertain that many epithelia are enlarged and contain globular and irregular secondary formations in their interior which have

Digitized by Google

been considered by pathologists as parasitic in nature. I hold the view of Virchow, that all these impacted formations are signs of active proliferation of the epithelia, the so-called "mother-cells", of old authors, tending toward a new formation of epithelia. The adenoid form of cancer is most frequently met in the uterus and in the alimentary tract, although in this case I was unable to trace any connection of the cancerous tumor with either the uterus or the rectum.

The third variety of cancer observed in this tumor is the so-called medullary form, which pathologists justly consider the most malignant. See Fig. 1.

We see some scanty tubular formations of adenoid cancer blending with a portion characterized by an abundance of epithelial nests and comparatively little fibrous connective tissue between them. Both the scirrhous and adenoid forms have contributed to produce the medullary type. The nests, though peg-like in the vicinity of the tubules, have assumed rather irregular forms, in which even the single epithelia-al cells have, in many instances, lost their angular shape to such a degree that a large protoplasmic layer may appear with scattered nuclei and occasional demonstrations of single epithelia-al cells, which, however, under all circumstances, remain interconnected by means of delicate threads.

In the adjacent connective tissue we see an active proliferation, most pronounced in the medullary portion of the tumor. There are numerous granules and globules ccattered throughout the connective tissue. This infiltration has long since been known by the name of "small cellular infiltration of Virchow", or "inflammatory reaction" of Thiersch and Waldeyer. It is interesting to inquire what may be the origin and significance of this proliferation in the connective tissue adjacent to all cancer nests, more especially to the adenoid and medullary varieties. The image offered by the connective tissue closely resembles the inflammatory condition.

We know that every new growth in the connective tissue first appears as a reduction to its medullary or embryonal condition, the same as takes place in ordinary inflammation.

Digitized by Google

Both cancer and sarcoma, in their commencement, present appearances similar to inflammation. It is only the final result that will determine the nature of the exuberant growth of the connective tissue or the epithelium, whether it is simply an acute inflammatory disturbance or a malignant tumor, sarcoma or carcinoma.

Around every growth we see this inflammatory reaction or infiltration. Virchow says: "If we examine any proliferating tumor of a cellular character we find, three to five lines beyond its apparent limits, the tissue already in a state of disease and exhibiting the first traces of a new zone[1]".

FIRST DISCOVERY:—INFLAMMATORY CORPUSCLES CHANGE DIRECTLY TO CANCER EPITHELIA.

When studying with high powers of the microscope, this "inflammatory infiltration", I noticed that some of the inflammatory corpuscles were shaping themselves into cancer epithelia. The indifferent or *medullary corpuscles were changing to large polyhedral epithelia-al cells, and forming cancer nests.* This, so far as I know, had never before been observed or demonstrated, and it completely sustains what Dr. C. Heitzman asserted in 1883, that the so-called small cellular infiltration of the connective tissue was the "pre-stage of cancer[2]".

This view is of great practical importance; and shows that in any operation for the removal of a malignant growth, *all the inflammatory infiltration around should be removed.* Whenever we see by the microscope this infiltration on the cut surface made by the surgeon, we can positively foretell a recurrence of the cancer in the given spot. We will always find this zone is the chief source of local recurrence after extirpation.

We see clearly the transformation of the basis substances into protoplasm. Both the free protoplasm between the bundles and the protoplasm of the basis substance grow

1. Cellular Pathology, p. 503.

2. Microscopical Morphology.

Digitized by Google

and proliferate. We see rows of newly formed elements between the bundles and the bundles themselves transformed into protoplasmic bodies, the final result being what pathologists term "inflammatory infiltration".

In the highest degree of this change only scanty spindle-shaped fibrilla are left between the groups of the embryonal or medullary corpuscles. At the same time we see that in the groups of medullary corpuscles numerous bodies had made their appearance characterized by an angular shape, by mutual flattening, and the appearance of large oblong nuclei; in short, bodies which offer all evidence of epithelia-al cells, although they had made their appearance, independently of previous cancer nests in the midst of embryonal or medullary corpuscles sprung from previous fibrous connective tissue.

SECOND DISCOVERY:—HOW CANCER EPITHELIA-AL CELLS ARE CONVEYED TO DIFFERENT AND DISTANT PARTS OF THE BODY.

The microscopical analysis of both ovaries revealed still more remarkable facts serving to illustrate the manner in which cancer is spreading. The right ovary was found in the state of the reactive infiltration just described. This may have been the result of a mere oophoritis, or of a beginning appearance of cancer. Since the right ovary contained several gyromata, and the inflammatory infiltration was most pronounced in the cortex of the ovary, and in the vicinity of the gyromata, I would consider part of this, at least, as subacute oophoritis. Quite different were the features of the left ovary. Fig. 2.

Here we see already with low powers of the microscope peculiar tracts pervading the medullary portion near the hilum. These tracts show coarsely granular irregular bodies clustered together in the shape of rows, exhibiting all the features of cancer nests. Higher powers of the microscope reveal the interesting facts that these rows of cancer nests are in the lymph-vessels, and that the lymph-vessels are dilated by, and are carrying the cancer epithelia-al cells. This proves, what has long been surmised, that cancer is conveyed to different and distant parts of the body by means of the lymphatics; but this is, so far

Digitized by Google

as I know, the first time it has been seen, or the fact positively verified, though it has generally been supposed to be the case, because the lymph ganglia near a malignant growth are the first to be affected. The endothelial lining of lymph-vessels is most conspicuous in the dilated portions where the cancer epithelia-al cells do not entirely fill the calibre. In the lymph-vessels the cancer epithelia-al cells have mostly lost their angular shape, being more or less rounded and coarsely granular, and showing a considerable increase of living matter toward an endogenous new formation. Some epithelia (K) show a karyokinetic change of the nuclei which leads to a division of the cancer epithelia. Besides these formations we meet with protoplasmic bodies mixed with epithelia-al cells not surpassing in size so-called lymph corpuscles, and between all these formations granules of varying size.

In Fig. 2, an entirely recent thrombus of the lymphatics is illustrated which is proved by the fact that as yet no change has taken place in the walls of the lymphatics or in their endothelium. That such changes do occur, and give rise to secondary tissue changes in the vicinity of the lymphatics, is proved by the study of other portions of the same specimen. See Fig. 3.

Here we notice peculiar changes of cancer epithelia-al cells, not only the indistinct karyokinetic change in some nuclei, but also a direct division of the epithelia-al cells into smaller pieces of protoplasm, known by the name of medullary or embryonal corpuscles. Whether the division is an indirect or direct one, the result is the same under all circumstances; it is the living matter of the protoplasm or the epithelia-al cells stored up in the nuclei and the granules in the surrounding protoplasm that causes proliferation.

Along the border of the lymph-vessels we still recognize the endothelial cells, which likewis are in a beginning proliferation by the outgrowth of their living matter into, first, coarsely granular, afterward vacuolated, and at last nucleated and reticulated bodies, exactly as we see in an acute inflammatory process. In several places in the specimen the wall of the lymph-vessel is

Digitized by Google

completely lost by inflammatory changes of the adjacent fibrous connective tissue. But the connective tissue corpuscles and the basis substance have undergone proliferation, which may lead to the appearance of medullary or inflammatory corpuscles, changes which penetrate the environments of the lymph-vessels to a varying depth, and as stated before, to be considered the commencement of pre-stage of a cancerous growth. One of the endothelia of an apparently normal lymph-vessel is illustrated at L. C. It shows a cluster of red-brown pigment granules, due to a previous hemorrhage.

The highest powers of the microscope thoroughly convince the observer of the tissue changes occurring around a cancerous thrombus in a lymph-canal. See Fig. 4.

The illustrated spot is more advanced in such changes than those drawn in Fig. 3. We see some nuclei in karyokinetic changes. In many epithelia-al cells the nuclei are broken up into a number of irregular lumps of living matter. We see a division of some epithelia-al cells into smaller pieces of protoplasm, interconnected with some origina epithelia-al cells by delicate threads. The lining endothelium of the distended lymph-vessels is changed everywhere, the changes consisting in an increase of the living matter of both the nuclei and the granules of the protoplasm. At the same time the adjacent connective tissue exhibits beautiful figures of proliferation from a small, just perceptible, granule into a solid, later a vacuolated, and at last nucleated mass of living matter; the last form being that usually described by authors as "protoplasm" or "cells". The basis substance of the fibrous connective tissue has, to a large extent, been liquified and transformed into protoplasm, so much so that only scanty spindle-shaped vestiges of such tissue are seen in the immediate vicinity of the lymph-vessels; whereas, some distance away, the beginning liquefaction of the basis substance is shown by the reappearance of living matter. The peritoneal cover of the left tube is broadened, its blood-vessels dilated, and the cortex crowded with medullary or inflammatory corpuscles. In a few places I was able to trace an increase in the size of the medullary corpuscles to that of cancer epithelia-

Digitized by Google

al cells so much so that I must attribute the inflammatory infiltration of the peritoneum not to peritonitis proper, but to a beginning invasion of the peritoneum with cancer.

My researches prove, beyond doubt, that the spreading of cancer from one organ, or from one tissue toward a neighboring one, is accomplished by the lymph-vessels. For centuries physicians and pathologists have been aware of the fact that the organs first affected by secondary cancerous growth are the lymph-ganglia in the neighborhood. It was a logical inference to conclude that the lymphatics were instrumental in conveyiug the poison of the cancer. It remained unsettled up to date whether the infection of the lymph-ganglia was affected by the so-called cancer-juice or by constituent elements of the cancerous growth.

No observation, as far as I am aware, has ever been made to corroborate the hypothesis of the pathologist. My studies have revealed the fact that the lymph-vessels carry the cancer poison not only to the neighboring lymph-ganglia, therefore, centrifugally, but into an organ which has no lymph-ganglia, only lymph-vessels, as the ovary. The specimen shows plainly that the poison is the cancer epithelia-al cells which are transmitted into the lymphatics, causing thrombosis of the lymphatics and infection around them. Whether or not the poison is lodged in parasitic organisms within the cancer epithelia-al cells I am unable to say. All attempts to prove the existence of such parasites have thus far proven failures.

Digitized by Google

Digitized by Google

PLATE XXVI.

Fig. 1. Carcinoma of Floor of Pelvis, Adenoid and Medullary Portion. x 200. *A*, adenoid or gland-like formations of cancer-epithelia; *M*, *M*, medullary portion of cancer; *I*, *I*, so-called small cellular or inflammatory infiltration of fibrous connective tissue; *F*, longitudinal bundles of coarse fibrous connective tissue; *N*, beginning formations of nests between the bundles.

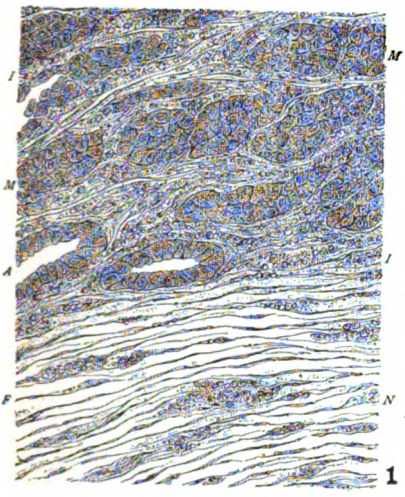
Fig. 2. Thrombosis of Lymph-vessels of Left Ovary with Cancer Epithelia. x 600. *C*, fibrous connective tissue of medulla of ovary near hilum; *M*, bundles of smooth muscle fibres; *L*, *L*, *L*, lymph-vessels with unchanged endothelial lining; *E*, *E*, cancer epithelium filling and extending the calibres of lymph-vessels; *K*, cancer epithelium whose nuclei show karyokinetic figures.

Fig. 3. Cancerous Invasion of Connective Tissue from Cancer Epithelium transported into lymph-vessels. x 600. *F*, fibrous connective tissue; *L*, *L*, lymph-vessels; *L*, *C*, lymph-corpuscles; *P*, pigment cluster from previous hemorrhage; *C*, *C*, cancer epithelium lying in lymph-vessels; *E*, *E*, endothelium of lymph-vessel in proliferation; *G*, outgrowth of living matter in endothelium and adjacent connective tissue.

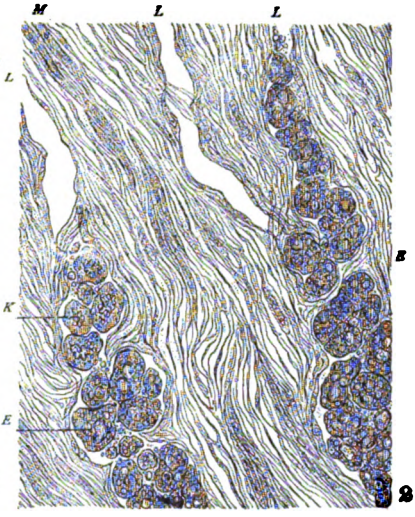
Fig. 4. Tissue Changes around a Lymph-Vessel filled with Cancer Epithelium. x 1,000. *F*, *F*, fibrous connective tissue unchanged; *C*, *C*, cancer epithelium in a lymph-vessel, coarsely granular, undergoing divisions; *E*, *E*, endothelium lining the lymph-vessel in active proliferation; *I*, *I*, proliferation of fibrous connective tissue environing the cancer thrombus.

Digitized by Google

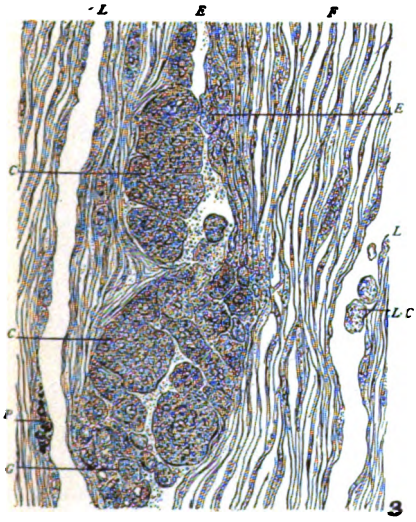
PLATE XXVI



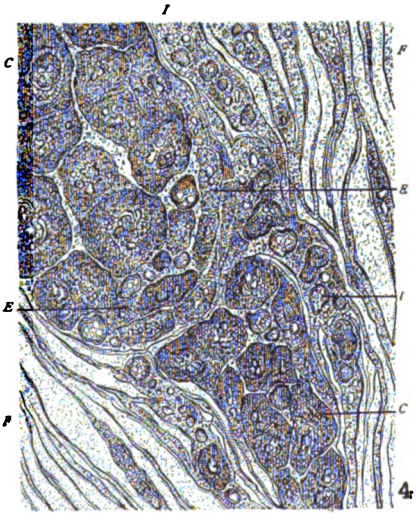
1



2



3



4

Digitized by Google

Digitized by Google

EFFECT OF HIGH ALTITUDE ON BLOOD COUNTS.

A. MANSFIELD HOLMES, A. M., M. D., DENVER, COLO.

Much speculation has resulted from the various investigations on the influence of altitude on blood counts. This subject involves so many factors that if the results are to be of scientific value much care must be taken both in the accuracy of the technique employed, and in the interpretation of the phenomena. My studies in hematology have, for some time, directed my attention to this problem. Many interesting studies have been made in this line of work in the Alps and other parts of the world; but so far as I have been able to ascertain, a careful study of this subject has not been made in the mountains of the United States. The altitude of Pike's Peak, in the vicinity of Denver, has presented the opportunity for making such a study. I, however, was not able to avail myself of this opportunity until the early part of last September (1898).

All hematologists recognize the fact that the counting of the red and white cells of the blood is a more or less inexact procedure. Discrepancies are unavoidable; but for scientific purposes precautions can be taken which diminish these errors to the minimum. Similar difficulties are met with in the estimation of the hemaglobin, an approximately accurate estimate of which requires extended practice and a keen sense of color perception. A few words as to the method adopted in this study are probably not out of place. The instruments employed were a microscope, Fleischel's hemometer, and Thoma-Zeiss hemacytometer. It might be as well to state at this time that a uniform method of study was used in each count, the same instruments were employed, and the usual sources of error in making such counts were, as far as possible, avoided.

Digitized by Google

In normal blood it has been ascertained that for every white cell there are about five hundred red cells. It is evident to all who have used the Thoma-Zeiss instrument that in making a count of the red and white cells over an area large enough to furnish five hundred red cells, there may be no white cell found, while in an adjacent area two or more white cells may be found. Therefore, the ratio of red cells to white cells, as determined by a count of one such area, may have a wide variation. Mathematically, if we let X equal the number of white cells, then $\frac{500}{X}$=R=*ratio of red to white cells.* When X=0, R=∞ (infinity); X=1, R=500; X=2, R=250; etc. On the average, when X is equal to 1, we may conclude that the probability of error in the count of white and red cells is 500 against the white. How may we diminish the probability of error? This is a question which I have considered, and for my own use have adopted the following method:

I use the highest power dry lens that can be focussed on the blood in the Thoma-Zeiss cell. By counting the red cells in fifty squares, and the white cells in four hundred squares we reduce the *ratio of error* eight times; 500÷8=62, 5=R′. Also I use an objective which will give a field of vision with a diameter five or six times greater than the side of one of the squares of the Thoma-Zeiss cell. Any variation in either direction can be readily adjusted by increasing or decreasing the tube length of the microscope. Using my Bausch and Lomb microscope with a No. 6 lens, 1 inch objective, and tube length 163 mm., I obtain a field of vision with a diameter equal to the side of six squares, which equals $\frac{6}{10}$ mm. Therefore $r^2=\frac{3}{10}$; the area, $r^2=3.1416 \times \frac{3}{10}=.070686$ sq. mm.,= area of field of view. In other words, by counting 14.14 fields of view we obtain the number of blood cells in 1 sq. mm. By counting 84.84 fields of view we obtain the count of cells equal to 6 sq. mm. Therefore by adding the number of white cells found in the 400 squares to those found in 84.84 fields of view beyond the checkered scale, we obtain the number of white cells found in 7 sq. mm. of surface, which is the equivalent of 99 fields of view. (84.84 plus 14.14=98.98). The

Digitized by Google

total number divided by 7, the number of sq. mm., will give an average very close to the true number. The probable error is now reduced from 62.5 to 8.9=(62.5÷7=8.9=R″).

In the following studies I uniformly counted the red cells in fifty squares of the Thoma-Zeiss cell, or the equivalent of one-eighth of one sq. mm. of surface. The white cells were counted over a surface equivalent to 7 sq. mm. The blood was diluted with Toison's Solution, 1 to 100; thoroughly mixed, and studied immediately. Two counts were made, each coming from the same diluted specimen of blood, the mixture being thoroughly agitated before taking the drop utilized for counting. The shortest possible time intervened between the two counts; the same Thoma-Zeiss instrument was used, and the same precautions used in mixing the contents of the instrument before the drops were taken. In each count, as far as possible, a drop of the same size was used and the same care exercised in applying the cover glasses. The blood studied was taken from the tip of the finger, punctured by a triangular pointed needle. In each study I have adopted the average of the two counts for my report as being approximately closer to the actual number.

I have been particularly interested in comparing the results of the first and second counts made from the same diluted specimen of blood, and have also compared these estimates with those obtained by the use of Deland's hematocrit.

In my experience the Thoma-Zeiss instrument has been more satisfactory, although I must confess that I have not used the hematocrit except on a few occasions, and then for the purpose of comparing the two instruments. In the following study I made use of my own blood. In this connection it will be necessary to be, to a slight degree, personal. At the time of making the study I was in good health. I was, however, in need of rest. I left Denver on September 8th, 1898, for Colorado Springs, and commenced the experiments on the following day.

First Study.—Made at Dr. Gildea's residence, Colorado Springs, September 8th, 1898, at 11:45 a. m., two hours after

Digitized by Google

breakfast. The temperature was 52° F. The count resulted as follows: White cells, 10,700; red cells, 4,968,000 per c. mm. Hemaglobin unfortunately was not estimated at this time on account of not having the instrument at hand.

It was my intention to ascend Pike's Peak on the following day, but a storm prevented. On the second day following I made the ascent with the following report:

Second Study.—Made at the Iron Springs Hotel, Manitou, Colorado, September 11th, 1898, 6:30 a. m., before breakfast. Temperature, 45° F. The count was as follows: White cells, 8,900; red cells, 5,104,000 per c. mm. Hg. 100 per cent.

Immediately after completing this count I breakfasted and took the train for Pike's Peak, arriving at the top of the Peak at 11 a. m. Through the courtesy of Mr. B. M. Rastall, the agent of the Pike's Peak railroad at the top of the mountain, I was permitted to use one of the windows of the station, the building formerly used as the United States Signal Station.

Third Study.—Made on top of Pike's Peak, 11:15 a. m. Temperature 15° F. Storming. Blood taken before luncheon. Count: White cells, 8,000; red cells, 5,668,000 per c. mm. Hg. 95 per cent.

Fourth Study.—Made on top of Pike's Peak, 2:15 p. m., three hours later. Temperature 9° F. Storming. Blood taken immediately after luncheon. Count: White cells, 9,300; red cells, 5,840,000 per c. mm.

On completing this study the train was ready to return to Manitou and I was unable to estimate the hemaglobin.

Fifth Study.—Made at the Iron Springs Hotel, Manitou, 9 p. m. on the same day. Temperature 40° F. Moderating. Blood taken two hours after dinner. Count: White cells, 10,800; red cells, 5,352,000 per c. mm. Hg. 100 per cent.

For convenience I have arranged the data of the foregoing studies in tabulated form.

Digitized by Google

TABLE I.—STUDIES OF MY OWN BLOOD.

	Time	Place	Altitude	Leucocytes per c. mm.	Red Cells per c. mm.	Hg. per c.	Temp.
First Study	Sep. 9, '98 11.18 a. m.	Dr. Gildea's office, Colo. Springs, Colo.	6,098*	10,700	4,968,000		52° F.
Second Study	Sep. 11, '98 6.30 a. m.	Iron Springs Hotel, Manitou, Colo.	6,318	8,960	5,104,000	100	45° F.
Third Study	Sep. 11, '98 11.15 a. m.	Top of Pike's Peak	14,184	8,000	5,668,000	95	15° F. Storming
Fourth Study	Sep. 11, '98 2.15 p. m.	Top of Pike's Peak	14,184	9,800	5,840,000		9° F. Storming
Fifth Study	Sep. 11, '98 9.00 p. m.	Iron Springs Hotel, Manitou, Colo.	6,318	10,800	5,352,000	100	40° F. Moderating

*The altitudes in this table are those obtained from the U. S. Signal Service.

Digitized by Google

During the short period that I remained at the top of the mountain, I ascertained that Mr. Rastall, the agent of the railroad, had been residing there for almost six months, and had made only occasional trips to Manitou, and on these trips never remained longer than a few hours. Through the courtesy of Mr. Rastall I was permitted to study his blood during the time I was at the top of the mountain, and he kindly returned to Manitou with me to enable me to make a second study, to observe the effect of a sudden change to a lower altitude.

First Study.—Made on top of Pike's Peak, September 11, 1898, 1 p. m. Temperature 9° F. Storming. Blood taken immediately after luncheon. Count: White cells, 10,600; red cells, 6,788,000 per c. mm. Hg. 110 per cent.

Second Study.—Made at Iron Springs Hotel, September 11, 1895, 3:30 p. m. Temperature 40° F. Modeating. Blood taken before dinner. Count: White cells, 15,500; red cells, 6,620,000. Hg. 110 per cent.

These observations are recorded in tabular form on the opposite page (Table II).

Blood films were also taken at the time of making the various counts. These films have been stained and a differential count made. The tabulated report of these differential counts both from my own blood (Table III) and from Mr. Rastall's (Table IV), are given on page 184.

Digitized by Google

TABLE II.—STUDIES OF MR. RASTALL'S BLOOD.

	Time	Place	Altitude	Leucocytes per c. mm.	Red Cells per c. mm.	Hg. per c.	Temperature
First Study	Sep. 11, '98 1.00 p. m.	Top of Pike's Peak	14,184	10,600	6,788,000	110	9° F. Storming
Second Study	Sep. 11, '98 5.30 p. m.	Iron Springs Hotel, Manitou, Colo.	6,318	15,500	6,620,000	110	40° F. Moderating

Digitized by Google

TABLE III.—DIFFERENTIAL COUNTS OF MY OWN BLOOD.

	Time	Place	Altitude	S. L.	L. L.	Trans.	Phag.	Eos.
First Study	Sep. 11, '98 6.30 a. m.	Iron Springs Hotel, Manitou	6,318	34	11	1	54	0
Second Study	Sep. 11, '98 11.15 a. m.	Top of Pike's Peak	14,184	30	8	1	60	1
Third Study	Sep. 11, '98 2.15 p. m.	Top of Pike's Peak	14,184	25	10	1	63	1
Fourth Study	Sep. 11, '98 9.00 p. m.	Iron Springs Hotel, Manitou	6,318	19	18	0	63	0

TABLE IV.—DIFFERENTIAL COUNTS OF MR. RASTALL'S BLOOD.

	Time	Place	Altitude	S. L.	L. L.	Trans.	Phag.	Eos.
First Study	Sep. 11, '98 1.00 p. m.	Top of Pike's Peak	14,184	39	4	1	53	3
Second Study	Sep. 11, '98 5.30 p. m.	Iron Springs Hotel, Manitou	6,318	30	7	0	61	2

Digitized by Google

Let us now compare the foregoing studies and observe the effects produced on the blood count by the sudden changes in altitude. By referring to Table I, it will be observed: First, that between the second and third studies there was an interval of four hours and forty-five minutes. Second, during this period I made the ascent from the Iron Springs Hotel, Manitou, to the old Signal Station at the top of the Peak; the increase in altitude being 7,816 feet, or, approximately, one mile and a half. Third, during this period the red cells showed an increase of 564,000 for each c. mm. Fourth, these two counts were made before breakfast and luncheon, respectively, and yet the variation in the count of white cells was scarcely apparent. Fifth, during the interval of three hours between the third and fourth studies, while remaining on the top of the mountain, the number of red cells made a further increase of 172,000. In other words, during a period of seven hours and forty-five minutes the number of red cells increased 736,000 per each c. mm. Sixth, in the fifth study, made on returning to Manitou, equally as important phonomenon was observed. The interval between the fourth and fifth studies was six hours and forty-five minutes. During this period there was a decrease in altitude of 7,816 feet, and the number of red cells decreased 488,000 per each c. mm.

It will therefore be recognized from these studies: First, that a sudden change from a low to a high altitude produces *a rapid increase* in the number of red cells. Second, that a sudden change from a high to a low altitude produces *a rapid decrease* in the number of red cells.

The percentage estimation from Table I is as follows: Taking the count made at Manitou in the morning as the standard, the first count made on top of the mountain, four hours and forty-five minutes later, shows an increase of 11.5 per cent. The second count made on top of the mountain, three hours later, shows an increase of 14.42 per cent. Hence there was an increase of 2.92 per cent during the three hours on the top of the mountain.

Digitized by Google

On returning to Manitou in the evening the count remained 4.86 per cent higher than in the morning before starting for the top of the mountain. It will therefore be observed:

First. That the red cells increase *immediately* on making the ascent of the mountain.

Second. That the number continues to increase during a residence on the mountain.

Third. That the number suddenly diminishes on returning to a lower altitude.

Fourth. That the rate of decrease is not as pronounced as the rate of increase.

By comparing the second study of Mr. Rastall's blood, made at the Iron Springs Hotel, Manitou, with the first study, made at the top of the mountain four hours and thirty minutes earlier, we observe a decrease of 168,000 per each c. mm., or 2.47 per cent. By making a similar comparison of my own studies, comparing the fifth study with the fourth, we observe a decrease of 8.35 per cent, the interval between the studies being six hours and forty-five minutes. If these two cases are to be compared, it would seem that the blood of persons residing in a high altitude for a long period is affected to a less degree on returning to a lower altitude, than that of one who remains in a high altitude for a short time.

Numerous explanations have been offered to account for the apparent increase in the number of red cells in high altitudes; but before proceeding to look for an explanation, the factors which may, directly or indirectly, influence this change, should be considered. In order to eliminate, as far as possible, all factors except those due directly to altitude, the shortest possible intervals between the counts should be considered of not a little importance. The long intervals between such counts in the majority of the reports made heretofore, impressed me with the necessity of making counts with short intervals between them, and yet to have the advantage of the great difference in altitude. Pike's Peak, with its great elevation and a railroad running to the top, offers advantages for such a study not equalled at any other point.

Digitized by Google

The U. S. Signal Station was opened at the top of Pike's Peak September 8, 1892, and remained until October 1, 1894. The records of this Bureau show that for September, 1893, and September, 1894, the mean atmospheric pressure was equivalent to 17.91 cubic inches of mercury. Also the mean temperature for September, 1893, was 32.4° F., and for September, 1894, 29.2° F. It is estimated that one cubic inch of mercury at 4° C. weighs .49 pound avoirdupois. Hence, the weight of 17.91 cubic inches of mercury will be nearly 8.79 pounds. Therefore, the mean atmospheric pressure on Pike's Peak during September, 1893 and 1894, was approximately 8.79 pounds to the square inch.

Denver is one mile above sea-level. The atmospheric pressure at such an elevation is about twelve pounds to the square inch. This is about three pounds to the square inch less than at sea-level. A person passing suddenly from sea-level to such an altitude frequently experiences a sudden dilation of his entire vascular system as a result of the diminished resistance of the atmospheric pressure. After a prolonged residence at such an elevation, the nervous system adjusts itself to the changed conditions and very little inconvenience is experienced. Those who have made the trip to the top of Pike's Peak have experienced the effects of the diminishing atmospheric pressure from 12 pounds to 8.79 pounds.

The smaller amount of oxygen in the atmosphere at high altitudes is also an important factor. Red cells possess a strong affinity for oxygen, and are distinctly oxygen carriers.

Each organism is accustomed to, and demands, a definite amount of oxygen. The respiration and circulation are automatically adjusted in accordance with the ease or difficulty with which this need is satisfied.

Under the conditions existing in high altitudes the difficulty of supplying the organism with the needed oxygen is increased. Hence, it would seem that under such conditions there is a need for a greater activity of the total volume of red cells, to absorb the amount of oxygen necessary for the organism. This necessarily brings into activity many red cells which, under

Digitized by Google

different conditions, probably remain in a more or less quiescent state in deeper portions of the body.

How far these influences are responsible for the variation in the count of the red cells of the blood at varying altitudes, it is not the purpose of this study to investigate. The able experiments of Regnard, Egger and others have gone extensively into this department of the study.

Digitized by Google

PHOTO-MICROGRAPHY WITH OPAQUE OBJECTS.

W. H. WALMSLEY.

It is a matter of no little regret to the lover of the microscope and its wondrous revelations in the realms of Nature invisible to the unaided sight, that the wide class of subjects which may be embraced in the comprehensive title or term of Opaque Objects is so greatly neglected of late years. This is alike true of both modern instruments and observers. The microscopes of twenty years ago were abundantly supplied with objectives of moderate and low powers suited to their examination, and with accessory apparatus for their illumination under the most diverse conditions, whilst much space in the text books was devoted to the same subject. But with the general introduction of the instrument into schools of all grades and its practical employment in a multitude of arts and sciences, most of these accessories have been eliminated from its outfits, until a microscope as now generally furnished comprises merely a simple form of stand with a couple of objectives of moderate and fairly high powers and a double nose piece. "Only these and nothing more". Vast fields of investigation are undoubtedly within the scope of its capacities, but the wonderful beauties of form and outward structure in the untold myriads of Nature's lavish handiwork, remain but as a sealed book to the great majority of observers. With the aid of the most advanced modern methods in staining and cutting sections, the minutest structure of a tissue is revealed to the practised eye, which may be almost or entirely ignorant of that of its envelope. How many of the students of the present day know anything of a mucous surface for instance, injected with opaque pigments and viewed under a proper illumination? Yet nothing can be more beautiful or instructive. So too with

Digitized by Google

innumerable other subjects. The seeds of plants with their infinite forms and markings: pollens, spores, scales and hairs of leaves and stems, endless in variety and beauty. In the insect world we have the compound eyes of many a fly glowing with gorgeous beauty, the scales upon the elytra and bodies of many beetles, and the wings of butterflies and moths, the fairy-like eggs, among the loveliest productions of Nature. In the mineral kingdom may be found minute crystals of every form and hue. But it is useless to extend the list, it is inexhaustible in subjects that will repay the most careful examination for purposes of either study or recreation.

The reproduction of opaque objects as seen under the microscope, for purposes of illustration and record, is no less important than that of transparencies. As a matter of course—in the author's opinion—photography offers the most satisfactory method of so doing. With suitable lenses and careful illumination it is but little if any more difficult than the photographing of transparent substances, yet no one seems to have done anything heretofore in this direction, with the single exception of photographing metallic surfaces under high powers; a most important subject which has received considerable attention and added greatly to the world's knowledge of these structures, within the last three or four years. Excepting these, however, I have never seen a photo-micrograph of an opaque object, nor a single line from any pen bearing upon the subject. If such exist they have not come under my observation.

It is hoped that these few preliminary remarks may not prove useless or uninteresting as an introduction to the equally brief notes or hints as to the making of this class of photo-micrographs, the following of which has led to fairly good results in the author's hands.

Any microscope, with or without inclination to body, may be used. The results are better with, than without an ocular, and the latter should be, if possible, especially constructed for the purpose—as Zeiss' projection eyepiece for example. It should be capable of carrying and focusing a three-inch objective, which power is useful for many comparatively large or

Digitized by Google

coarse objects. The outfit of lenses should include a two-inch objective but need not go above ⅛, the most useful work being done with 1½-in. to ½-in. A plano-convex or bull's eye condensing lens on stand is indispensable. If possible, a Lieberkühn for each objective and a parabolic silvered reflector should be included in the outfit, though the latter pieces of apparatus are rarely found in these days with any microscope, especially of American manufacture.

Artificial illumination *may* be used; even the somewhat dim coal oil lamp, which, however, requires inordinately long exposures. The acetylene gas light is altogether the best from an artificial source I have ever employed, and is quite satisfactory in time and quality. But altogether the best light for the purpose is diffused daylight from a window with northern exposure, than which nothing can possibly be better. If the camera is constructed so as to permit the use of the microscope in a vertical position, so much the better, as proper lighting of the object is more readily secured than when the instrument is inclined horizontally, an even illumination, avoiding deep shadows, giving the best results in most cases, and this is the more readily obtained when the object lies in a horizontal plane. Some objects are better shown under a diffused light, such as may be obtained near a window without the interposition of a condenser. If its color be dark or reflect but little light, the bull's eye should be used focused upon the specimen, care being taken to avoid glare or excess of illumination which will result in a confused image in the negative. With some subjects the Lieberkühn may be used advantageously, with others the parabolic reflector, but the majority yield better results under the most simple forms of illumination. A very little practice will enable the operator to determine this for himself, in widely differing cases.

The character of plates to be used for the negatives is probably of more importance than those for transparent objects. They should be of a good degree of sensitiveness but not too rapid, must be capable of giving great density if desired and should develop equally well with all mediums, so that the

Digitized by Google

worker may employ that with which he is most familiar. The best and most satisfactory paper I have ever used is the "Velox", a modified bromide, capable of being handled by daylight but sensitive enough to be printed by lamp or gas-light, and giving black and white prints of the most exquisite and permanent qualities. The illustrations accompanying this paper are printed on "Glossy Velox" which I have found to yield results superior to those obtainable on the matt surface. Some specimens are better delineated by allowing the light from the sky to fall as nearly perpendicular as possible upon them. Others again show better by throwing the light obliquely across their surfaces by means of the bull's eye condenser or parabolic reflector. They should always be carefully studied under various methods of illumination before making any attempt to photograph them, in order to determine upon the best resolution and definition of their several features. No. 2 of the illustrations was made with the light reflected from a white cloud and falling directly upon the object without the intervention of a condenser. The others were lighted from the same source, but with a condenser so arranged as to throw the light across their surfaces, causing slight shadows. The result is strikingly shown in No. 3 from a slide of Cuxhaven diatoms, mostly discoid forms. As seen with the page in proper position, many of them present the appearance of shallow dishes or saucers, containing others of smaller dimensions; reverse the page and print and this appearance is entirely lost. With these three photographs the illumination was from the front of the microscope.

The possibilities of this class of photo-micrography for real work or recreation only, are very great; the field boundless. I trust that others may feel inclined to enter upon it and that we may hear from them in the future.

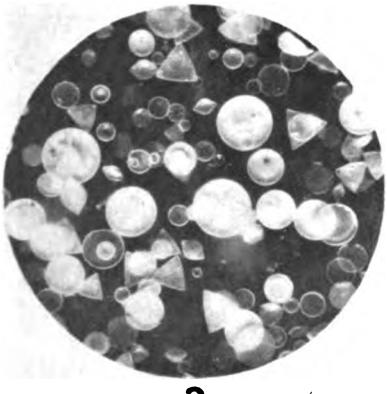
The explanation of Plate XXVII may be found in the text.

Digitized by Google

PLATE XXVII

1

2



3

4

Digitized by Google

Digitized by Google

ON THE NORTH AMERICAN SPECIES OF THE GENUS ATAX (FABR.) BRUZ.

ROBERT H. WOLCOTT.

GENERAL CONSIDERATIONS.

One who opens many of our fresh-water mussels, cannot fail to notice, in part of them at least, dark spots upon the mantle or gills, which a moment's observation will show are living, moving organisms. A lens will reveal the fact that they have four pairs of six-jointed legs and a pair of five-jointed palpi, but no antennæ-like structures, that the head, thorax and abdomen are fused into one mass with no trace of segmentation, and that the relatively long legs are clothed with spines and hairs which assist in swimming. Two small blackish or brownish eyes may be detected near the anterior margin. These characters point to the taxonomic position of these creatures in the order Acarina or Mites and in the family Hydrachnidæ or Water-Mites, while their presence in the mussel suggests their membership in the genus *Atax*, the members of which are mussel-parasites, during at least a part of their existence. Rarely representatives of other non-parasitic genera may be found within these shells, but their occurrence there is purely accidental; on the other hand few species of this genus are found except in mussels. However, the genus is not confined to the Unionidæ, a single species having been found in the mantle-cavity of a South American gasteropod, *Ampullaria*, related to our genus *Campeloma*, and the author having detected another previously described species in a species of *Sphærium*, one of the Cyrenidæ.

In scanning the literature on the subject we discover but scattered references to Hydrachnidæ, under the generic term *Acarus*, previous to 1781, when O. F. Müller described 49 species from Denmark, establishing for them the new genus

Digitized by Google

Hydrachna. In 1793, J. C. Fabricius included all these under *Trombidium*, but in 1805 he established the genus *Atax* which was equivalent to *Hydrachna* of Müller. Previously, in 1796, P. A. Latreille had erected the genera *Limnochares* and *Eylais*, but these were by Fabricius included under *Atax*. In 1834, Antoine Dugès restricted the name *Hydrachna* to a few species which are still so classified, re-established the genera *Limnochares* and *Eylais*, and separated from *Atax* Fabricius, which included the greater number of the species, the additional genera *Diplodontus* and *Arrenurus*. In 1837 the genus of Fabricius was still more sharply limited by C. L. Koch, who separated several new genera; but only in 1854 and by Ragnar Bruzelius was the genus *Atax* reduced to the limits which were for forty years accepted by all students of the group as its natural bounds and are by many still so regarded. In 1894 Richard Piersig, on grounds considered insufficient by Koenike, separated from *Atax* the genus *Cochleophorus*, and in the past year, 1897, he has proposed another new genus, *Encentridophorus*, to include a species described by Koenike from East Africa, and the genus *Najadicola* to include one of our American species, also described by Koenike. The characters which separate *Cochleophorus* from *Atax*, as thus limited, are sufficient, it seems to the author, to render the former a valid genus; certainly the two designate clearly defined groups of species and all described forms fall naturally into one or the other of these groups. In accordance with this view the species included under *Cochleophorus* are excluded from this paper. In regard to *Najadicola*, however, while it possesses certain characters which differ from those of other species of parasitic mites, the writer has been unable to agree with Piersig in thinking these differences such as to entitle it to more than sub-generic rank.

As in the above manner limited, the characters of the genus *Atax* are thus defined by Piersig in his "Deutschlands Hydrachniden" (97):

Body soft, with but a slight tendency to the formation of chitinous thickenings over the surface, round or oval; on the

Digitized by Google

anterior margin no concavity; the posterior margin evenly rounded or with a shallow median concavity. The first pair of legs distinguished by an unusual thickness and in the non-parasitic species provided with long, stout, movable, sword-shaped spines, inserted into prominently projecting papillæ. Second pair usually exceeding the third in length. The proportion between the length of the body and legs quite variable, but generally the legs of the parasitic species shorter than those of the non-parasitic. The maxillary shield is not fused with the neighboring epimera. In ventral view it resembles in shape a broad chalice. The palpi are long; in the parasitic forms they equal or exceed in thickness the first pair of legs. The next to the last segment possesses on its ventral side three papillæ varying in size in different species; of these the one at the outer end ends in a chitinous spur, while the two others placed somewhat farther posteriorly are each crowned with a little hair. The fifth palpal segment is short and provided with chitinous claws. Among the epimera those of the fourth pair are distinguished by their size and more or less rectangular form. Third epimeron imperfectly separated from the fourth. Genital area at the extreme end of the body. The chitinous plates surrounding the genital cleft from either side, bear together 10, 12, or numerous, acetabula. In the females characteristic sword-like spines appear in the vicinity of the genital opening, which are employed in oviposition.

This diagnosis is not strictly applicable to all of our species, even excluding *Atax* (*Najadicola*) *ingens* (Koenike), since both *A. abnormipes* mihi and *A. indistinctus* mihi are deeply emarginate posteriorly, *A. pectinatus* mihi is a non-parasitic form yet lacks the movable spines on the first pair of legs, and the genital area is not in all forms at the extreme end of the body, though usually approaching that position.

The sub-genus *Najadicola* differs in the following respects. The fore legs are not thickened, and all are short, with few short spines and simple claws. The genital area is not at the end of the body but immediately behind the last epimera and as Koenike's figures show, bears a certain resemblance to

Digitized by Google

that of *Cochleophorus*. It is, however, much broadened transversely, and each genital plate is triangular in outline. There are no spines about the genital opening of the female and the lack of these is correllated with the method of oviposition, *A.* (*N.*) *ingens* Koenike depositing its eggs in masses between the gills and not in them.

Of the genus *Atax* as thus defined there have been heretofore described 22 valid species, distributed geographically as follows:

From Europe, 8: *A. aculeatus* Koenike (Germany), *A. Bonzi* Claparède (Germany, Sweden, Switzerland, France, Russia) *A. crassipes* (Müller) (Finland, Russia, Switzerland, Denmark, Germany, Italy, France), *A. figuralis* Koch (Germany), *A. intermedius* Koenike (Belgium, Germany, Russia), *A. limosus* (Koch) Berlese (Italy, Germany), *A. tricuspis* Koenike (Germany) *A. ypsilophorus* (Bonz) (Sweden, Germany, Switzerland, France).

From Asia, 3: *A. crassipes* (Müller) is recorded from Palestine, and *A. Schmackeri* Koenike was described from Shanghai, China, while Daday has recently published one from Ceylon, *A. singalensis*, while his *A. nodosus* belongs to *Cochleophorus*.

From Africa, 1: *A. lynceus* Koenike from East Africa.

From Brazil, 6: *A. Ampullariæ* Koenike, *A. fissipes* Koenike, *A. Jheringi* Koenike, *A. perforatus* Koenike, *A. procurvipes* Koenike, *A. rugosus* Koenike, all from the province of Rio Grande do Sul.

From Guatemala, 3: *A. alticola* Stoll, *A. dentipalpis* Stoll and *A. septem-maculatus* Stoll.

A. alzatei Alf. Dugès, described from Mexico, is a species of *Curvipes*.

From North America, *A. ypsilophorus* (Bonz) has several times been recorded and Koenike adds to it from Canada *A. fossulatus* Koenike and *A.* (*N.*) *ingens* (Koenike).

Our own literature is not entirely wanting in references to this genus, but the work done by Americans has for the most part been practically worthless, while efforts made to secure the original specimens have resulted in failure, as would be ex-

Digitized by Google

pected from the number of years that have elapsed, the nature of the specimens, and the crudity of methods of preservation in vogue at the time they were described.

Thos. Say, in 1821, described *Hydrachna triangularis* from *Unio carinatus* Say; in so doing he may have re-described *Atax ypsilophorus* (Bonz) as other authors have inferred, although from his description it is impossible to say which species he had under observation. In 1836, James D. Dana and James Whelpley, in Silliman's Journal, described two forms, *Hydrachna formosa* from "*Anodonta cataracta*" (*A. fluviatilis* Dillw.) and "*Unio purpurata*" (an incorrect identification as *U. purpuratus* Lam. is Southern in its habitat); and *Hydrachna pyriformis* from *Margaritana undulata* Say. The former is another synonym of *A. ypsilophorus* (Bonz), the latter a distinct species, but the characters given are not sufficient for exact determination. Its form and the character of the claws which are described as simple, seem to show that it is a female of either *A. abnormipes* mihi or *A. indistinctus* mihi, but of which it is impossible to tell. In 1842, S. S. Haldeman described under the "Genus? *Unionicola*" nine species: *oviformis*, *lactea*, *personata*, *humerosa*, *symmetrica*, *proxima*, *lugubris*, *unicolor* and *reticulata*—with very short descriptions, based mostly on color. Two of the nine are identical with *A. ypsilophorus* (Bonz), while the other seven are probably the same, as Koenike (95b) suggests. Joseph Leidy, in 1883, noted the presence of the same European form in *Anodonta fluviatilis* Dillw. from New Jersey, and mentions the occurrence in *Unio complanatus* Sol. of a second species, "probably", he says, "*A. Bonzi*", also a previously described European form. In 1891, F. Koenike of Bremen, Germany, published a preliminary account (91c) of some material received from Dr. Tyrrell in Ottawa, Canada, confirming Leidy's observation as to the occurrence of *A. ypsilophorus* (Bonz) in North America, but, and it seems rightly, throwing doubt on his identification of *A. Bonzi* Claparède. In 1895, a fuller paper (95b) on the same material by the same author appeared and in it he enumerated the species previously

Digitized by Google

mentioned—*A. ypsilophorus* (Bonz), *A. fossulatus* Koenike and *A. (N.)ingens* (Koenike).

The collection of material upon which the present paper is based was begun in 1893 and has been carried on, as opportunity offered, ever since. During the five years the following collections of Unionidæ have been made and examined for mites:

August, 1893, at Lake Saint Clair, Mich., 257 specimens of *Unio gracilis* Barnes, *U. luteolus* Lam., *U. nasutus* Say, *U. alatus* Say, *U. ventricosus* Barnes, *U. gibbosus* Barnes, *U. rectus* Lam., *U. coccineus* Hild., *U. undulatus* Barnes, *U. occidens* Lea, *Margaritana rugosa* Barnes, *M. deltoides* Lea and *Anodonta ovata* Lea.

October, 1893, at Lansing, Mich., from the Cedar River, about a score of mussels, belonging to several species, the record of which is, unfortunately, lost.

July and August, 1894, at Charlevoix, Mich., from "26" Lake, Twin Lakes and Susan Lake, small inland lakes in the vicinity, and from Round Lake, opening into Lake Michigan, and also from Intermediate Lake at Ellsworth, Mich., 116 specimens of *U. luteolus*, *M. rugosa*, *A. subcylindracea* Lea, *A. footiana* Lea, *A. edentula* Say and *A. fragilis* Lam.

August, 1894, in two small lakes on Beaver Island, L. Michigan, 85 specimens of *U. luteolus*, *A. footiana*, *A. fragilis* and *A. marryatana* Lea.

July and August, 1895, from Grand River and smaller streams, and from Reed's Lake, near Grand Rapids, Mich., 273 specimens of *U. coccineus*, *U. gibbosus*, *U. ventricosus*, *U. occidens*, *U. rectus*, *U. undulatus*, *U. plicatus* Lea, *U. alatus*, *U. ligamentinus* Lam, *U. spatulatus* Lea, *U. Novi-eboraci* Lea, *U. rubiginosus* Lea, *U. pustulosus* Lea, *U. Schoolcraftii* Lea, *U. verrucosus* Barnes, *U. luteolus*, *M. rugosa*, *M. marginata* Say, *A. ovata*, *A. edentula*, *A. footiana*, *A. subcylindracea*, *A. fragilis*, *A. imbecilis* Say.

July, 1897, from Rogue River, Kent County, Mich., and from Reed's Lake, Grand Rapids, Mich., 21 specimens of *U.*

Digitized by Google

occidens, *U. spatulatus*, *M. deltoides*, *M. marginata*, *A. footiana*, and *A. subcylindracea*.

August, 1895, at Long Lake, Kalamazoo, Mich., 13 specimens of *U. luteolus*, *U. ventricosus* and *A. footiana*.

August, 1895, at Black Lake, Holland, Mich., 10 specimens of *U. luteolus* and *U. ventricosus*.

July and August, 1898, from various localities along Grand River, near Grand Rapids, Mich., from the mill-pond at Mill Creek, near Grand Rapids, from Reed's Lake, and from Plaster Creek, in the same vicinity, 534 specimens of the species previously enumerated from the same localities, with the addition of *U. pressus* Lea.

August, 1898, at White Lake, Muskegon county, Mich., 86 specimens of *U. luteolus*, *A. subgibbosa* Anth., *A. subcylindracea*, *A. footiana* and *M. complanata* Barnes.

August, 1897, at Lake Winnebago, Oshkosh, Wis., 21 specimens of *U. gracilis*, *U. luteolus* and *A. grandis* Lea.

October, 1894, from Blue River, Crete, Neb., 2 *Unio luteolus*.

October, 1894, from pools near Lincoln, Neb., 19 specimens of *U. parvus* Barnes, *U. subrostratus* Say, *U. jamesianus* Lea and *A. grandis*.

October, 1894, from Platte River, South Bend, Neb., 1 *A. grandis*.

October, 1894, from Weeping Water Creek, Weeping Water, Neb., about 50 specimens of *U. subrostratus*, *U. rubiginosus*, *U. undulatus*, *U. jamesianus* and *M. complanata*.

September, 1895, from the same locality, 24 of the same species.

September, 1895, from near Lincoln, Neb., 20 *U. lachrymosus* Lea, *A. plana* Lea, and *A. decora* Lea.

September, 1897, from the Blue River, at Milford, Neb., 42 specimens of *U. lachrymosus U. ventricosus*, *U. Schoolcraftii*, *U. anodontoides* Lea, *M. complanata*, *A. plana* and *A. grandis*.

Thus, personally, the author has examined nearly 1,600

Digitized by Google

specimens of Unionidæ, representing a large number of localities and 39 species.

Through the kindness of Mr. R. H. Johnson of Harvard University the material obtained from the following mussels has been received for examination:

Angust, 1897, from Lake Chautauqua, New York, 150 specimens of *U. phaseolus* Hild., *U. gibbosus*, *U. luteolus*, *A. edentula* and *A. plana*.

August, 1897, from Cayuga Creek, Cheektowaga, Erie county, N. Y., a number of *U. occidens*.

To Prof. H. M. Kelly of Cornell College, Mt. Vernon, Iowa, the author is indebted for the data and mites obtained from the examination of the following large number of mussels, collected during the years 1896 and 1897:

From the Illinois River and bayous and lakes near Havana, Ills., 731 specimens of *U. alatus*, *U. asperrimus* Lea, *U. anodontoides*, *U. cornutus* Barnes, *U. donaciformis* Lea, *U. ebenus* Lea, *U. ellipsis* Lea, *U. graniferus* Lea, *U. elegans* Lea, *U. gibbosus*, *U. Higginsii* Lea, *U. gracilis*, *U. laevissimus* Lea, *U. ligamentinus*, *U. luteolus*, *U. lachrymosus*, *U. metanever*, Raf., *U. multiplicatus* Lea, *U. parvus*, *U. pustulatus* Lea, *U. pustulosus*, *U. rubiginosus*, *U. plicatus*, *U. securis* Lea, *U. tenuissimus* Lea, *U. trigonus* Lea, *U. rectus*, *U. tuberculatus* Raf., *U. ventricosus*, *M. rugosa*, *M. marginata*, *M. confragosa* Say, *M. complanata*, *A. imbecilis*, *A. plana*, *A. suborbiculata* Say, *A. edentula* and *A. corpulenta* Coop.

From the Spoon River at Bernadotte and Duncan's Mills, Ills., 194 specimens including the greater number of the above species.

From Abbey Creek and Cedar River, Mt. Vernon, Iowa, 486 specimens, including also the majority of the same species.

From the Susquehanna River at Lewisburgh and Sunbury, Pa., and the Schuylkill River and French Creek near Phoenixville, Pa., 202 specimens of *A. edentula*, *M. undulata*, *M. marginata*, *U. complanatus* Sol., *U. heterodon* Lea, *U. nasutus*, *U. ochraceus* Say and *U. tappanianus* Lea.

Digitized by Google

Mr. M. Ricker of Burlington, Iowa, has kindly sent a small collection of mites obtained at Havana, Ills., from the same species of Unionidæ enumerated in the above list.

The present paper embodies, thus, the results of the examination of nearly 3,500 mussels, representing 60 species, and from them have been collected and preserved about 7,000 mites, belonging to 13 species, of which 7 are new and 3 more are reported from America for the first time. Search has been made for mites in *Pisidium* and *Sphærium* but with success in only one instance, when two individuals of *A. crassipes* (Müller) were found in a species of *Sphærium*, and in *Campeloma*, *Physa*, *Limnea* and *Goniobasis*, but so far without results.

In this enumeration and throughout the paper the author has avoided any attempt to pass judgment upon the validity of the different species of mussels referred to, and has included many names which he himself believes to be synonyms, as for instance, *Unio occidens* Lea and *U. ventricosus* Barnes, in order that there should be in this way no omissions of species which others might believe distinct from those given. All the names given have been more or less generally recognized and the reader is requested to make his own synonymical corrections in accordance with his opinions.

The specimens of mites obtained were studied alive, preserved in various fluids, and mounted upon slides to allow of thorough microscopical examination. Without, at first, sufficient knowledge of the weight of specific characters, too much dependence was placed upon color, which, it is found, has almost no value in identification, though the brilliancy of coloration is one of the principal features which make the group such an exceedingly attractive one for study. Later certain structural characters were fixed upon, which, by their similarity in allied species, led to confusion; and differences, too, which were at first assumed to be sexual, were found later, when the true sexual characters were discovered, to be specific. Finally, especially at first, the mites collected from a single species of mussel and bearing a close resemblance were assumed to be identical and only found to include more than one species after

Digitized by Google

the accumulation of individuals in vials prevented the correction of the recorded notes. These, together with a lack of that familiarity with the Unionidæ necessary to make sure identifications at the time of examination and consequent occasional confusion in the recording of observations, impair the value of early notes and collections. The facts are mentioned that others may be warned thereby, and in order that certain allusions in the descriptions which follow may be understood. It may be said here, that in the case of more recent collections, care has been taken to keep the mites from each mussel separate until careful examination under the microscope, of the structure of palpi, legs, genital area, etc., has allowed of exact identification of each individual mite.

As to preserving fluids, alcohol, corrosive sublimate, picro-sulphuric, Flemming's and other solutions were at first used. Of these corrosive sublimate gave the best results, but all have been rejected as making the specimens too brittle and leading to serious breakage of appendages. Formol does not preserve the color effectually and is partly open to the same objections. Yet a certain proportion of the specimens collected have always been preserved in either it or the media previously mentioned, to allow of their being studied in various ways. A solution recommended by Koenike (91c) and consisting of

Glycerine.....2 parts by vol.,
Distilled water.....3 parts by vol.,
Glacial acetic acid.....2 parts by vol.,
Absolute alcohol.....1 part by vol.,

has been found to preserve the specimens in the best condition for future study, since although it cannot be recommended as a preservative either of form or color, it keeps the body soft and the appendages pliable, and thus they lend themselves the more readily to methods of preparation used in making slide mounts.

A solution consisting of

Glycerine.....10 parts by weight,
Citric acid, concentrated solution, 3 parts by weight,
Distilled water.....10 parts by weight,

to which is added, when the mites have regained their plump

Digitized by Google

form after being first shrivelled by being put into the mixture,

Absolute alcohol.....1–10 of the total volume,

is recommended by Koenike (96) as an improvement over his previous formula, and has been of late used in place of it, without sufficient time having elapsed to judge of its merits.

In the preparation of slide mounts, specimens are removed from the preservative, thoroughly washed in distilled water, treated with a dilute potassium hydrate solution, a rent made in the skin and through it the contents of the body pressed out, again thoroughly washed, passed through the grades of alcohol and clearing mixture and finally mounted in balsam. By this means a perfectly transparent mount is obtained and all the hard parts are readily studied. There is more or less distortion, but comparison with specimens preserved in other media assists in obtaining a correct view of the relations of the hard parts, which are themselves in perfect condition. The mouth-parts are removed from the body, separated by dissection and also mounted for detailed examination.

The study of the material collected has resulted, as before stated, in the detection of 13 species, of which 7 are new and have been briefly described in a preliminary paper published in the Zoological Bulletin for June, 1898. The list is as follows:

1. *Atax crassipes* (Müller).
2. *Atax aculeatus* Koenike.
3. *Atax pectinatus* mihi.
4. *Atax intermedius* Koenike.
5. *Atax abnormipes* mihi.
6. *Atax indistinctus* mihi.
7. *Atax serratus* mihi.
8. *Atax fossulatus* Koenike.
9. *Atax stricta* mihi.
10. *Atax arcuata* mihi.
11. *Atax ypsilophorus* (Bonz).
12. *Atax tumidus* mihi.
13. *Atax* (*Najadicola*) *ingens* (Koenike).

In the arrangement of these species in the order given, an attempt is made to preserve the sequence in which the Eu-

Digitized by Google

ropean forms have usually been arranged and with the end in view of bringing allied species together. First the two free-living forms, together with a third, parasitic in habit, but resembling the other two very closely in form and structure, fall naturally into what may be called the *crassipes* group, *A. crassipes*, *A. aculeatus* and *A. pectinatus*. Then the forms in which the hind leg of the male is modified and in which, in the same sex, the body is more or less strongly emarginate posteriorly and which in both sexes have the distal segment of the palpus broad and tipped with two prominent curved claws, form a second group, the *intermedius* group, including *A. intermedius*, *A. abnormipes*, *A. indistinctus* and *A. serratus*. A third group includes *A. fossulatus* and *A. stricta*, with 5 acetabula on each side, in the female set into the surface of the body, in the male on a genital plate; while *A. arcuata*, *A. ypsilophorus* and *A. tumidus* form a not very homogeneous group, the members of which are related in form of body, character of genital area, etc., and which in structure and position of the genital area show a gradual transition towards *A.* (*N.*) *ingens*, which itself is related on the other hand to *Cochleophorus*.

In the descriptions which follow, the terms used need no explanation except perhaps with reference to the palpi and legs; the former are supposed to be extended parallel to the long axis of the body, whence the terms inner and outer, dorsal, extensor or upper, and ventral, flexor or lower, as applied to the corresponding surfaces. The legs are supposed to be at right angles to the body and the terms anterior and posterior become applicable. The names applied to various parts are such as have hitherto been applied or are literally translated from the corresponding terms in use by European writers on the subject.

Measurements have been taken with an ocular micrometer. The length of the body is that of the body proper, and the projecting mouth-parts are not included; the length of a segment is the length of a straight line connecting the middle points of its two ends; and the total length of an appendage is the sum of such lengths of the segments which compose it. In

Digitized by Google

all measurements of legs which follow the claw is not included in the total. For the sake of brevity the legs and the epimera corresponding are frequently referred to by Roman numerals and the segments of the legs and palpi are numbered from the base outward, using Arabic numerals; thus "III 3" refers to the third segment of the third pair of legs, and "Palpus 5" to the distal segment of the palpus.

DESCRIPTION OF SPECIES.

I. Atax crassipes (Müller).

Hydrachna crassipes Müller, 1776; 189, no. 2254: id., 1781; XLI, Pl. IV, f. 1, 2.

Trombidium crassipes Fabricius, 1792; II, 400.

Atax crassipes Fabricius, 05; 366: Koch, 35; 7, 21: id., 37; III, 8, Pl. I, f. 1.

Atax elegans Koch, 35; 7, 12.

Atax truncatus Koch, 35; 7, 22.

Atax albidus Koch, 35; 7, 23.

Atax confluens Koch, 35; 7, 24 (nymph).

Atax truncatellus Koch, 35; 37, 17 (nymph).

Hydrachna crassipes Walckenaer and Gervais, 44; III, 197.

Atax crassipes Bruzelius, 54; Pl. I, f. 1–4: Claparède, 68; 471: Kramer, 75; 293: Lebert, 79; 368, Pl. XI, f. 10, 10a; Neuman, 80; 21, Pl. I, f. 1: Koenike, 81a; 627: id., 81b; 356: Haller, 81a; 76: Berlese, 82; fasc. IV, no. 7: Krendowsky, 85; 55: Barrois and Moniez, 87; 5: Piersig, 94b; 214: Koenike, 95a; 139: id., 96a; 232: Piersig, 96; 40: id., 97; Lief. I, 52, Pl. III, f. 5, a—h.

Atax crassipes is noteworthy among the species of this genus, for the great length of its legs, which cover a greater area than those of any other species, though its body is smaller than many others. The body of the male varies in length from 0.5 to 0.7 mm., while the female is from 0.7 to 0.9 mm. and even 1.1 or 1.2 mm. long. Its form is broadly oval, with the larger end of the oval anteriad and evenly rounded, the smaller end posteriad and truncate, projecting nipple-like papillae at either side giving this end the appearance of having been cut squarely off. The greatest breadth is about opposite the third epimeron. The nipple-like papillae exhibit varying degrees of prominence and Piersig describes a muscle which serves as a retractor and by which they may be made to completely disappear.

The double eyes are very large, blackish in color, close to the margin and moderately distant from each other, in a specimen 0.618 mm. long being 0.184 mm. apart. The anterior portion of each eye is larger and nearly twice as large as the posterior.

Digitized by Google

The mandibles are nearly typical in form, though a little longer than the average for the genus, the maximum width being equal to about one-third the length, which in the specimen just referred to is 0.148 mm. The greatest breadth is near the posterior end; the dorsal margin is slightly concave, the posterior dorsal angle rounded, the posterior ventral angle produced, forming a point of muscle attachment, and the ventral margin nearly straight; a shallow mandibular groove is present. The distal segment includes about one-third the total length, and most of this is made up by the slightly curved and rather slender claw, which is indistinctly hooked at the tip and marked on the inner side toward the base by slightly curved oblique striae, which are vertical to the line of insertion of the claw.

Palpi, long and slender, segment 1 about half as thick as it is long: 2 the thickest of all and nearly as thick as long; 3 about two-thirds as thick as 2, and a little over half as long; 4, longest of all, but only about half as thick as 2; 5 slender, curved, at the base nearly as thick as 4, but at once strongly contracted and throughout most of its length with the dorsal and ventral surfaces nearly parallel. From above or below the palpi appear even more slender than from the side, the extreme width of 2 at about the middle being only three-fourths of its thickness and the palpus tapering gradually and evenly from this point to the tip which is blunt and bears very small claws; 2 has two small spines on the outer side close together and near the dorsal margin, and one on the inner side near the middle, with a second very small one close to the base; 3 has a very long stout spine in the middle of the outer side and one smaller but still long and stout on the dorsal side near the distal margin. On 4 are the three papillae characteristic of the genus, the two being but a little beyond the middle of the segment, the third at the distal margin, and all three being exceptionally long and slender. The outer of the two is the longest and its length equals the thickness of the segment, the third at the distal end is about two-thirds as long as the outer, and the inner of the two only about one-third as long. The two bear each a small hair, the third a broad chitinous cap. There is, finally, a long slender hair on the outer side of this segment near the base.

The maxillary shield, as far as its main portion is concerned, is broad, short and evenly rounded posteriorly, with a rather prominent rostrum anteriorly; the ancoral process is nearly as long as is the main portion, is broad at its base, its lateral margins forming with the anterior part of the margin of the former a nearly straight line; and tapers to a narrow tip, which is produced to either side forming recurved hooks.

The epimera are rather large, especially the posterior group, and the spaces between the groups are narrow in the male, wider in the female. The posterior margin of the anterior group is strongly convex while at one- third the distance from the inner to the outer end and opposite the suture between I and II, the two give rise to a long curved process which runs back to a considerable distance beneath III. The separation between III and IV is represented by a line at about two-fifths the distance from the anterior margin and which curves from the outer side obliquely

Digitized by Google

inward and forward about half way acrosss the plate formed by the two. This plate is nearly rectangular, somewhat longer than broad, with the anterior margin slightly concave, and the inner slightly convex. On the thickened border at the inner posterior angle are two hairs.

The legs, as before stated, are very long, all considerably exceeding the body in length. Measurement of several specimens show a variation in the relative length of legs and body and in the relative lengths of the legs themselves, but this variation seems to possess neither locality, sexual nor specific significance. In a single specimen from Lake St. Clair the third pair of legs exceeds in length the first, but in all other cases III is the shortest, nearly equalling I, and II and IV are considerably longer, with IV a little longer than II and more than twice the length of the body. In all cases the order of length of the individual segments in II and III is as follows, beginning with the longest—5, 4, 6, 3, 2, 1; in I, 5 and 6 are of about equal length, and both shortened, being shorter than 3; in IV, 6 is lengthened and surpasses 4. In the case of I, 2 possesses a ventral papilla, projecting chimney-like to a distance equal to two-thirds of the thickness of the segment, deeply excavated and open at one side and receiving into this excavation a long movable spine, while there is also a short movable spine at the outer margin of the posterior side; 3 has two movable spines on either side ventrally; 4, four in two ranks on the proximal half of the ventral surface; 5 a row of four towards the base and one at the tip on the ventral side, of the former the first and third being the longer. All of these spines are widest at a little distance from their insertion tapering gradually to a blunt tip, and more rapidly to their point of insertion. The fifth segment has the dorsal surface produced forming a scoop-like shield over the insertion of the next segment. 1, 2 and 3 are very stout, 4 tapers considerably towards the tip, 5 and 6 being noticably slenderer and 6 somewhat curved. II, III and IV are slenderer at the base than I, and taper gradually from base to tip; they possess a moderate number of long, slender, straight spines which form groups on the tips of segments II 5, III 4, III 5, IV 4 and IV 5, while on IV 3, numerous spines are scattered along the ventral surface. On I the claws are rather stout, much curved and bifid, the ventral of the two tips being the stouter; on the other legs, however, the claws are longer, much more slender and the two tips are long, slender and sharply pointed, while the dorsal of the two is not so long as the other and thus forms an accessory claw arising at a distance from the tip equal to one-fourth the length of the claw.

The genital cleft in the female is flanked by four chitinous plates, of which the two anterior are irregularly rectangular with rounded angles and the two posterior roughly triangular with the angles also rounded. Each bears three acetabula and numerous slender spines, and six longer and stouter spines are borne—two each by the anterior plates and one each by the posterior—on their contiguous angles which are somewhat produced and directed outward. The male also possesses twelve acetabula but they are borne on two lunate plates, one on either side, and are distributed on each plate in two groups of three each.

Digitized by Google

On either side of the genital area is a large nipple-like papilla, which varies in prominence, and which, according to Piersig, can be retracted by a muscle running to it from the last epimeron. Koenike (81b) believes these papillae to contain highly developed epidermal glands.

MEASUREMENTS,

	Male. juv. Grand Rapids, Mich.	Male Beaver I'ds.	Female Beaver I'ds.	Female Lake St. Clair.
Length of body,	0.367 mm.	0.701 mm.	0.835 mm.	1.002 mm.
Length of leg I,	0.688 mm.	1.234 mm.	1.357 mm.	1.596 mm.
Length of leg II,	0.842 mm.	1.525 mm.	1.657 mm.	2.081 mm.
Length of leg III,	0.632 mm.	1.198 mm.	1.285 mm.	1.632 mm.
Length of leg IV,	0.872 mm.	1.596 mm.	1.708 mm.	2.112 mm.
Length of palpus,	———	0.357 mm.	0.398 mm.	0.403 mm.

Atax crassipes was first met with Sept. 1st, 1893, in material dredged over a bed of Chara in Anchor Bay, Lake St. Clair, at a depth of about 3 meters. Specimens were again secured near the same locality on the 3d, and in that vicinity again on the 12th, at a depth of 5 meters. It was collected in the southwestern part of the lake on the 8th and 10th at depths of 5 and 6 meters respectively, and off Point Pelee Island, Lake Erie, on the 17th, at a depth of 5 meters. Altogether 29 specimens were secured. It appeared to be of general distribution over the Chara which carpets the bottom of Lake St. Clair, a lake which though of an area of 410 sq. miles is over its deeper portion only about 6 meters in depth.

During the summer of 1894, specimens, parasitic as well as free, were collected at several points in Northern Michigan. They were found in Round Lake at Charlevoix, July 9th to 13th, at depths of 16 to 18 meters, in limited numbers; July 31st a specimen was secured in bottom collections from Lake Michigan off Fisherman's Island, a few miles west of Charlevoix, at a depth of about 10 meters, and on August 18th the species was obtained in bottom tows in Lake Michigan between Beaver and High Islands at depths of 10 and 23½ meters. Aug. 6th the species was found at Twin Lakes and "26" Lake, small inland lakes near Charlevoix, on Aug. 21st at Susan Lake, another similar lake in the vicinity, and in material collected on the same day at Intermediate Lake, also not far distant. Sept. 5th Dr. R. H. Ward collected specimens

Digitized by Google

at Dodge Creek, Emmet County, so that the species may be accounted as generally distributed throughout the smaller inland lakes of Northern Michigan, and also in Lake Michigan and the smaller lakes in connection with it, though present nowhere in large numbers. Mr. Bryant Walker, a conchologist and a member of the same party as the writer, turned over to him two specimens of an *Atax* from *Sphærium simile* Say, collected in "26" Lake Aug. 6th, and on the 17th of August specimens of adults and nymphs were secured in considerable numbers from *Anodonta footiana* and *Anodonta fragilis* taken in a lake at the north end of Beaver Island, Lake Michigan. All of these have been carefully studied from mounts and the author has been unable to detect any characters by which any of them may be distinguished from *Atax crassipes*.

Specimens were collected at Grand Rapids, Mich., during the months of July and August, 1896 and 1897, in Reed's and Fisk's Lakes, and in a third very small lake near the city. The former are lakes of moderate size and with a depth of 20 meters or more, but the latter is hardly more than a pool in the midst of a cranberry bog, 50 meters across, and with scarcely more than a meter of clear water above the loose, half-floating, semi-decayed vegetable mould which forms the bottom of such lakes. All are spring-fed. Two specimens, apparently of this species, were collected in two examples of *Anodonta fragilis* from Reed's Lake, July 23, 1898.

From Mr. J. B. Shearer have been received specimens collected in Quannecussec River, an arm of Saginaw Bay, Lake Huron, in the Kawkawlin River, an affluent of the same bay, and at Les Chenaux Islands, in northern Lake Huron, near Mackinaw, all obtained during August, 1895.

In Wisconsin, the author has collected this form in Lake Winnebago, at Oshkosh, Sept. 2, 1897, while he has received it from two localities in Nebraska,—in a collection made by Dr. H. B. Ward at a lake at South Bend, Sept. 2, 1897, and from material obtained by Mr. O. D. Noble in a "stagnant spring-fed pool" at Linwood, Sept. 1898.

Digitized by Google

2. ATAX ACULEATUS KOENIKE.

Atax crassipes juv. Claparède, 68; 471, Pl, XXXIII, f. 1-3.

Atax aculeatus Koenike, 90; 188: id., 95d; 386, f. 13: Piersig, 96; 40, footnote: id., 97; Lief. I, 59, Pl. I, f. 8.

A. aculeatus is very closely related to *A. crassipes* and can best be described by comparing it directly with that species. It is similar in form, but so far as the author's observation goes never reaches as great size, the males attaining a length of from 0.5 to 0.6 mm., the females 0.65 to 0.75 mm.

The mandibles are similar in form as is also the maxillary shield. The eyes are very large, black and rather close together.

The palpi share in the resemblance, though they are apparently a trifle more slender and are proportionately longer.

The epimera occupy even more of the under surface of the body and in the male the four groups are almost in contact.

The legs are very long as in *A. crassipes* and the proportions similar, though those of *A. aculeatus* seem slightly stouter than in the allied species. The sixth segment is, however, somewhat longer in III and exceeds 4. In I, 4 is the longest and 5 and 6 approximately equal to each other, while both exceed 3; 6 is also not quite so slender as is the case in *A. crassipes* and is less curved and a little dilated at the tip. The arrangement and length of the spines on the legs are practically the same in the two species. The claws are similar.

The genital field in the present form is characteristic and markedly different from that of *A. crassipes*. There are but ten acetabula instead of twelve, in the male situated on two kidney shaped plates which flank the genital cleft. On each side two anterior acetabula are placed one directly behind the other, and are separated by an interval from the three posterior, of which the two anterior lie side by side. The cleft is longer than in *A. crassipes* and in the case of all specimens on slides gapes widely. In the female the single lateral plate is divided into two, the anterior of which is pouch-shaped with the neck of the pouch directed anteriad, while the posterior is similar in outline but inverted. The former has two acetabula, the latter three. The ovipositor is prominent and of characteristic form. From each side of the genital opening projects a plate which anteriorly and—since the genital area is on the posterior surface of the body—also, ventrally, is produced and turned outward forming a conical process, at the top of which is articulated a short, thick, sharply-pointed spine. At the base of this, internally, is a small sharply-pointed process, and from the posterior—and dorsal—margin projects a longer, tapering and sharply pointed process, both of these processes being not set into sockets, but apparently continuous with the rest of the plate. By the apposition of these two plates, they are able, probably, to serve together as an ovipositor.

Digitized by Google

At either side of the genital area is a conical papilla, similar to that found in *A. crassipes* but still more prominent.

MEASUREMENTS.

	Male	Female
Length of body	0.601 mm.	0.668 mm.
Length of leg I	0.943 mm.	1.244 mm.
Length of leg II	1.168 mm.	1.453 mm.
Length of leg III	0.918 mm.	1.147 mm.
Length of leg IV	1.199 mm.	1.601 mm.
Length of palpus	0.301 mm.	——

In the examination of mussels from Grand River, at Grand Island near Grand Rapids, Mich., July 9, 1896, nymphs of different species of mites and also dead mites were found in the mucous about the exhalent aperature of many individuals. Little notice was taken of these until in *Unio ligamentinus*, *U. alatus* and *Anodonta edentula*, a few adults were found; these were, however, on cursory examination, supposed to be *Atax crassipes*. A more thorough examination later showed them not to be that species and to belong probably to *Atax aculeatus*, a determination which has since been verified. On the 5th of July, 1897, six specimens were found along the edge of the mantle of *Unio spatulatus* from the Rogue River, Kent County, Mich. During the past summer especial care was taken to examine all mites and nymphs occurring in the situations referred to. It was found that most of them were nymphs and of these the majority were *A. abnormipes*, a smaller number were *A. aculeatus*, a still smaller, *A. intermedius*, and now and then one of *A. serratus* or *A. fossulatus*, all of these species being reared from such nymphs. Of all, only *A. aculeatus* was represented by adults, while this species in its adult form seemed to occur nowhere but along the margin of the mantle and about the exhalent and inhalent aperatures, situations which its slender form and superior activity enable it to maintain. The mussels from which it was obtained were *U. rectus*, *U. gibbosus*, *U. undulatus*, *U. ligamentinus*, *U. occidens*, *U. ventricosus*, *U. spatulatus*, *U. Novi-eboraci*, *U. coccineus*, all from different localities along Grand River, north of the city of Grand Rapids, Mich.; *Unio pressus* and *Anodonta plana*, from Plumb's Creek,

Digitized by Google

near that city; and *Unio luteolus*, from White Lake, Muskegon County, Mich. The dates were from July 27th to August 30th.

8. ATAX PECTINATUS WOLCOTT.

Atax pectinatus Wolcott, 98; 280.

A species, in the character of the genital area allied to *A. crassipes* and *A. figuralis* Koch, but with the legs relatively shorter than either and with the palpi very thick, considerably thicker than the basal segment of the first pair of legs. The claw of this pair of legs is broad, flat and deeply pectinate, which character suggests the specific name.

It is of medium size as compared with the other species of the genus, the males measuring 0.7 to 0.8 mm., the females 0.8 to 1.0 mm. in length respectively. The body is broadly elliptical with the antero-posterior diameter but slightly greater than the transverse, which is greatest at a point about midway between the anterior and posterior extremities. The posterior margin is smoothly rounded and the surface is uniformly smooth and without chitinous thickenings of any kind. The males are somewhat slenderer than the females.

Eyes moderate in size, with the anterior of the two lenses the larger.

Maxillary shield relatively short and broad, with a prominent rostrum formed by the apposed anterior mesial angles of each of the two maxillary plates which are completely fused anteriorly. The posterior lateral angles are quite evident though rounded while the ancoral process produced by the apposition of the two produced posterior mesial angles is, as compared with other species, very weak.

Mandibles with a long, narrow proximal segment which is slightly broader posteriorly where it is directed somewhat ventrad and tapers to a bluntly rounded point, in front of which is a shallow mandibular groove. Its form is irregular owing to the undulating marginal outline. Distal segment large, with a broad basal portion and a sickle-shaped claw which is moderately curved except toward the tip, where the curvature is more pronounced and where it tapers somewhat more rapidly than before to a sharp point. The proximal half of this claw is marked by fine, wavy, oblique lines. Extreme breadth equal to about one-fourth its total length.

Palpi large and heavy, those of the female somewhat more than two-fifths the length of the body. Those of the male are very little smaller than those of the female in absolute measurement and are therefore larger in proportion to the size of the body. Basal segment short and broad. Segment 2 is the largest and much the thickest, equaling nearly one-half the total length and with a thickness in proportion to the length as 5:9. The flexor side is nearly straight, with a very slight concavity, the extensor side very convex and evenly so, making it much longer than the other and causing the planes of the two ends to be very oblique to one another. On the inner side of segment 2 are two flattened spines rather near together, at a distance from the basal margin of about one-third the length of the segment, and a third one-half the distance from these to the distal end, all three being nearer the extensor than the flexor side of the palpus. On

Digitized by Google

the outer side are two toward the extensor margin, the distance between them somewhat less than one-third the length of the segment. Segment 8 is much shorter than 2 and not so broad, yet broader than long. Its flexor side is half the length of the extensor, each of them with a slight convexity, and there is a small straight spine on the outer side, while 4 is longer and narrower, concave on its flexor surface, moderately convex on the opposite side. The former bears distally a pair of not very prominent papillae and a short spur at the distal margin. Segment 5 tapers at first rapidly, then more gradually to a blunt, rounded tip, produced slightly toward the flexor side and bearing at the distal end four short claw-like projections arranged in quadrille, while immediately proximad of them are two very short spines.

Epimera covering about the same proportion of the ventral surface as do those of *A. figuralis*, but II and III and those of opposite sides are separated only by very narrow spaces, narrower in the male than in the female. Outline of the fused I and II approximately triangular, the apex of the triangles of the two sides nearly meeting in the median line. The anterior margin of this triangular plate is slightly excavated and the posterior forms a double curve, being convex for the inner two-thirds of its length and beyond that concave. I is long and narrow, broadly expanded at its outer end, where it is moderately excavated to receive the first pair of legs, while II is broadly triangular with the anterior external angle truncate. The plate formed by the fused III and IV has a slightly concave anterior margin, a nearly straight inner margin, and a posterior margin slightly convex, all the angles being rounded. The epimera of the opposite sides approach each other most closely in front. A transverse suture two-fifths of the distance from the anterior to the posterior margin indicates the line of junction of the two epimera.

The legs are shorter than in the related species and relatively longer in the male than in the female. In the former I is slightly longer than the body, II and III about equal and each a little less than one-third longer, IV about two-thirds longer. I of the female is almost four-fifths of the body length, II and III somewhat exceed it and IV is greater by a little more than one-third. Of the individual segments 1 is the shortest and the others gradually increase in length to 5, but 6 is again shorter. I is slightly heavier than the rest, though as a whole the legs are decidedly weak and the distal segments especially slender. There are no movable spines on I set into projecting sockets as in *A. crassipes* and *A. figuralis*, their number is somewhat less, and individually they are shorter and more slender and taper to a sharp point. The claws are characteristic. Those on I are expanded dorso-ventrally and flattened laterally, forming a broad plate of which the dorsal margin is strongly arched, the flexor margin deeply pectinate, the pectinations, about sixteen in number, reaching nearly three-fourths the distance to the opposite margin, and with a slight curvature toward the base of the claw. The claws of the remaining legs are slender, strongly curved at the base, more moderately beyond, and again more strongly toward the sharply-pointed tip. On the whole the claw of II has the more pronounced curvature and is shortest, IV the

Digitized by Google

least pronounced and is longest. Each has a very inconspicuous tooth in the middle of the flexor margin.

The genital area is circular in general outline and is situated toward the posterior end of the body. It includes a genital cleft, flanked on either side in the male by one genital plate, in the female by two. The genital plates of the male are each lunate in form and bear six acetabula placed in two groups with a moderate interval between. In the female a transverse division along this line separates each plate into two, of which the anterior is irregularly quadrilateral, the posterior roughly triangular in outline, each bearing three acetabula.

MEASUREMENTS OF SPECIMENS DESCRIBED:

	Male	Female
Length of body	0.70 mm.	1.08 mm.
Length of palpus	——	0.44 mm.
Length of leg I	0.73 mm.	0.82 mm.
Length of leg II	1.00 mm.	1.14 mm. (approximate)
Length of leg III	0.98 mm.	1.15 mm. "
Length of leg IV	1.18 mm.	1.41 mm.
Length of mandible	——	0.292mm.
Length of genital area, median cleft	0.21 mm.	0.17 mm.

Types retained in the collection of the author.

This species was taken in the dredge at Lake St. Clair, September 1, 1893; later another was discovered in material collected a few days previous; and others were afterward collected in the vicinity of New Baltimore, Mich. Altogether six specimens were secured, but owing to breakage in transit of the bottle containing them, only two are available for description, and these, a male and a female, are to a certain extent distorted in mounting. Field notes taken at the time say: "Pinkish tinge to epimera and genital area. Legs and palpi blue of an unusally deep tint. Body deep olive brown, with a yellowish-brown Y-shaped mark. Eyes blackish."

4. ATAX INTERMEDIUS KOENIKE.

Atax ypsilophorus van Beneden, 48; 9 et seq., Pl.

Atax Bonzi "living free," Koenike, 81a; 626.

Atax intermedius Koenike, 82; 265: Lampert, 93; LXXIX: Piersig, 94b; 214: Koenike, 96a; 238: Piersig, 96; 40: id., 97; Lief. I, 46, Pl. I, f. 2, a–e.

A. intermedius is one of the smaller species, and especially small are the males, between which and the females there is a much greater difference in size than in any other of our species. The length of several of

Digitized by Google

each sex, measured from preserved specimens, proved to be from 0.75 to 0.95 mm. for the females and only about 0.5 or 0.6 mm. for the males.

The form is broadly oval, approaching elliptical, and with both ends evenly rounded. The skin shows a fine, even, parallel striation over the whole body of the female; the striae running transversely, while the epimera show the hexagonal reticulation which is characteristic of the group of species which has been referred to as the *intermedius* group. In the male the same reticulation is visible over the whole body, but is more pronounced and regular on the epimera.

Eyes large and rather distant from each other.

Maxillary shield relatively broad, especially posteriorly, where its thicker portion is evenly rounded, while the thinner and relatively slender ancoral process extends posteriad a short distance and ends in a broad tip, which is produced laterally to an unusual degree, forming recurved hooks. Line of separation between the two plates of which the shield is composed distinct.

Mandibles quite typical in form, the basal segment rectangular, broader posteriorly, with the dorsal posterior angle rounded, ventral posterior angle produced and a shallow mandibular groove on the ventral side. Distal segment moderate, claw rather small and slender, and moderately curved.

The palpi are as a whole quite slender, being only a little thicker than the first pair of legs, and in many respects are characteristic. The basal segment is not unusual; but 2 is much longer along the dorsal margin than along the ventral, the former being moderately convex, the latter nearly straight. It bears on the outer side and near the dorsal margin three long slender spines, two close together near the middle, a third toward the distal margin; on the opposite side are two spines near the middle. 3 is nearly straight along the dorsal margin, slightly convex along the ventral, and about half as long and two-thirds as thick as 2; it bears a long, slender spine on the outer side close to the proximal margin, and one on the inner side, close to the distal margin and also to the dorsal surface. 4 is the longest of all, yet only half as thick as 2; its dorsal margin is slightly convex toward the base and nearly straight beyond; its ventral surface is concave proximally, but convex distally where it bears the usual number of papillæ, of which the paired ones are characteristic. The outer of the two is short and inconspicuous, the inner very large, prominent and flattened laterally; in the male the latter is longer and slenderer, while the former is also longer. Both bear small hairs. Segment 5 is curved ventrad and is nearly circular in cross-section at the base, but at the tip is compressed laterally; it bears the usual terminal claws, which, however, are only moderately large and the whole segment is unlike that in the other species grouped with this.

Epimera in the female occupying about the anterior half of the ventral surface, in the male nearly the whole of it, leaving only room posteriorly for the genital area. Spaces between the groups also much wider in the female than in the male. In the former the first epimeron is nearly rectangular, and II irregularly triangular, with the inner end produced and

Digitized by Google

passing beneath the anterior margin of III. Of the posterior group, III comprises about one-third and the suture between it and IV runs obliquely inward and forward half way to the inner margin. Anterior margin slightly concave, inner and posterior slightly convex, with inner posterior angle rounded and those of opposite sides diverging. In the male all the epimera relatively much larger and the inner ends of the anterior groups nearly in contact. The posterior groups are not only nearly in contact but a chitinous bridge connects the two which thus become one mass which is somewhat emarginate posteriorly.

The legs are all longer than the body in the female and very much longer in the male. III is the shortest, I next longer, II next and IV the longest of all. They are of medium stoutness and taper slightly from base to tip. In I and II the three outer segments are, in order of length, beginning with the longest, 4, 5, 6; in III all are nearly equal, but 5 exceeds 4; and in IV, 6 is also longer than 4. The spines are moderately numerous on the legs of the female and are rather long, while those on 2, 3 and 4 of I are set into short excavated papillæ similar to those of *A. crassipes*, though not so prominent. A bunch of four or five spines on the proximal half of the ventral surface of I 4 is noticeable. On the ventral surface of 4 and 5 of both III and IV, there are numerous hairs, more abundant and smaller on IV than on III, longer at the tip of each than elsewhere. The legs of the male posess fewer spines than do those of the female, and in this sex IV is peculiar; 4 of this leg is curved, the concavity being on the posterior and ventral aspect of the segment, and at the tip on the same aspect is a bunch of very long spines. On the posterior surface of 5 and about the middle is a bunch of strong, feathered spines. The claws are similar in form to those of *A. ypsilophorus*, and as in that species, are received into a cleft in the end of the dilated tip of the segment.

The genital area is proportionately large and flanked in the male by one plate on each side, in the female by two. Each of the two in the male is broadly lunate in form and bears five acetabula in two groups—2 and 3 respectively—and numerous small spines. In the female the anterior plate on each side is rhomboid in shape, with the anterior and outer margins slightly convex, and the posterior concave; it bears two acetabula, which are larger than those of the male, and its inner margin is reflected outward, forming two blunt, moderately thick lips, the margin of each of which bears two short stout spines. The posterior plate is roughly circular with a projecting inner anterior angle and its anterior and inner margins are thickened, the inner also reflected, forming a broader and less prominent lip than that of the anterior plate, while at the inner anterior angle is a stout spine, and external to it on the anterior margin a second. On this plate are three acetabula.

Digitized by Google

MEASUREMENTS:

	Male	Female
Length of body	0.501 mm.	0.752 mm.
Length of leg I	0.643 mm.	1.112 mm.
Length of leg II	0.852 mm.	1.607 mm.
Length of leg III	0.627 mm.	0.959 mm.
Length of leg IV	0.867 mm.	1.571 mm.
Length of palpus	0.214 mm.	0.337 mm.

Of this species, 13 specimens were obtained at L. St. Clair, Aug. 17, 1893, from *Anodonta ovata* and Oct. 10, 1893, 22 specimens were collected at Lansing, Mich., from mussels taken from Cedar River, but unfortunately the record of species of Unionidæ has been lost. It was found in considerable abundance at Round Lake, Charlevoix, Mich., in *Anodonta subcylindracea*, *A. footiana*, *A. edentula* and *Unio luteolus*; at "26" and Twin Lakes, in *A. edentula*, *A. footiana* and *A. fragilis*, in limited numbers in the former but more abundantly in the latter lake; and at Intermediate Lake, in *Margaritana rugosa*, *Anodonta subcylindracea*, *A. footiana*, *A. edentula* and *A. fragilis*, but in none common. At Beaver Island, Lake Michigan, it was collected rather commonly in *Anodonta footiana* and *A. marryatana* taken from a lake towards the south end of the island. At Grand Rapids, Mich., during the summer of 1895, *A. intermedius* was found only in *Margaritana rugosa* from two localities on Grand River and only in limited numbers, while during the past summer the same was found to hold true. A few specimens were secured Aug. 17th to 20th, 1898, at White Lake, Muskegon County, Mich., from *Anodonta footiana* and *A. subcylindracea*.

In Nebraska it is a very abundant form, and on one occasion a very large *Anodonta plana* was fouud to contain 406 specimens. It has been collected in ponds at Lincoln, in Weeping Water Creek at Weeping Water and in the Blue River at Milford, from *Unio subrostratus* (once), *U. Jamesianus* (once), *Margaritana complanata* (occasionally), *Anodonta plana*, *A. decora* and *A. grandis*. The females are almost uniformly in excess, averaging three to each male; of 1178 specimens from the vicinity of Lincoln for example, 275 were males and 893,

Digitized by Google

females. There is usually a tinge of blue in the Michigan specimens, lacking in those from Nebraska.

5. ATAX ABNORMIPES WOLCOTT.

Atax abnormipes Wolcott, '98; 280.

Among the species to be considered in this paper are two which are quite different from all others, which bear a very close resemblance to each other and which are yet clearly distinct. They are both peculiar in the possession by the males of a highly modified fourth pair of legs, while the females present no marked structural peculiarity. The first of these is *Atax abnormipes*. It is one of the smaller species, the females averaging about 0.7 mm., the males about 0.55 mm. The body of the former is about one-sixth longer than broad, somewhat broader posteriorly and so slightly pyriform in shape and evenly rounded at both ends. In profile it is about two-thirds as high as long, flattened dorsally in the center, the outline descending abruptly at either end. The surface of the body is marked by lines dividing it into minute hexagonal areas, appearing facetted. The male is decidedly pyriform, with a breadth equal to four-fifths its length, the average of a number of specimens being 0.445 mm. and 0.56 mm. respectively. The body is smoothly rounded anteriorly, but deeply emarginate posteriorly.

Eyes very large, in the male measured, 0.148 mm. apart. Each lens nearly circular, the anterior a little the larger.

Maxillary shield.—Comparatively broad, the sides anteriorly nearly parallel, with the anterior lateral angles diverging. The ancoral process very broad with a width at the tip of over half the extreme breadth of the whole, inconspicuously hooked and with sides which from the tip diverge at once to the posterior lateral angles, which thus instead of appearing posterior, seem like projecting angles in the middle of each side.

Mandibles.—The basal segment is broadly rectangular, nearly as broad as long, slightly narrowed anteriorly, the dorsal posterior angle rounded, the ventral angle produced for attachment of muscles. Distal segment comparatively large, the claw rather heavy, slightly curved and quite blunt. Patch of oblique striae near its base sharply limited and with a broadly elliptical outline.

Palpi.—Whole palpus slender and somewhat less than one-half the length of the body. Basal segment short, while 2 is of moderate length, relatively thicker than the rest, and convex along both extensor and flexor margins, the convexity of the former the greater; on the outer side are two long, tapering, slightly curved spines toward the extensor margin; on the inner surface one, similar to the others, in the middle, and a second close to the distal margin. 3, somewhat narrower than 2 and proportionately ong, though hardly as long as broad; flexor margin nearly straight; extensor margin convex; a spine at the proximal margin of outer surface, nearer the extensor side, and another at the distal margin on the inner side. 4, long and slender, narrower than 3, about three times as long as thick and slightly tapering toward the end; paired papillæ on the flexor

Digitized by Google

margin two-thirds the way towards the tip, short, and with a slender spine, the third at the distal margin short and inconspicuous. 5, broad, laterally quadrate in outline, with the ventral distal angle produced and on the distal margin two slender, strongly curved claws, one near the extensor margin, the other about in the median line.

Epimera large, covering most of the under surface of the body and with a very narrow space between II and III and between those of opposite sides. I, rather broad, with parallel margins, the anterior margin concave, the posterior slightly convex. II, slightly broader than I and with its posterior margin quite convex and forming with the inner end of I a continuous curve. Line of separation between III and IV distinct one-half the way in from the lateral margin and one-fourth the distance from the anterior towards the posterior margin of the plate formed by the two. Anterior margin of III concave and anterior internal angle projecting. Posterior margin of IV strongly convex, indistinctly angulated, and produced backward to a point even with the genital area, which thus lies in an angle between the last two epimera. Lateral margin deeply excavated between the points of articulation of legs III and IV and opposite the division between the corresponding epimera. The surface of the body between the four groups of epimera is thickened and so to a certain extent all are fused into one mass. The surface of all the epimera is marked, as is the rest of the body surface, by a system of lines cutting it up into small hexagonal areas, and the same is true of the maxillary plates.

Legs.—In the male, very short and comparatively thick, the last especially so. I averages one-seventh shorter than the body and is shortest of all, III is one-seventh longer than the body, II a sixth longer and IV a fourth longer. Of the individual segments, 1 is shorter, 2 and 3 are about equal and next longer; 4 is longest except in IV where 6 is very long, exceeding it and all the others; while in I and II, 6 exceeds 5 and in III the reverse is true. The legs are all moderately well supplied with spines and are not noteworthy except in the case of III, 5 and IV, 4 to 6. The former has at its tip three doubly curved blade-like spines reaching three-fourths the way to the end of 6. Of the latter, IV 4 is compressed laterally through the distal two-fifths of its length and on this compressed portion bears a bunch of six very large spines, placed in two rows on the ventro-anterior surface, and exceeding in length the next segment, while on the posterior surface are about nine spines, of which six are moderately stout, while the three distal are very long and slender and reach beyond the distal end of 5 by about one-third its length. 5 is short, at its base narrower than 4, tapering toward the tip, with two very heavy, curved blunt spines on the extensor surface and a row of spines along the flexor side, and a bunch of fine hairs at the distal end, while 6 is very slender and rather long. All the claws are strongly bent and bifid, with an accessory tip on the convex side short and inconspicuous and ending at a distance from the end equal to one-sixth the whole length of the claw.

Digitized by Google

The legs of the female are slenderer and relatively shorter and III much shorter than in the male. IV, 4 is exceeded by both 5 and 6. There is no marked structural peculiarity; the segments of the last pair decrease regularly in thickness from 1 to 6; IV 4 lacks the six large spines; and IV 5 the two long ones, retaining the row of spines on the flexor surface.

The genital area of the male lies one-half on either side of the groove in the emarginate posterior end of the body, the opening being at its bottom; the latter is bounded by two rather broad lunular plates, each with five acetabula in two groups—two in front and three behind. In the female a transverse division indistinctly separates each of these lunules into two parts, the anterior with two, the posterior with three acetabula, and each bears at the angle adjacent to the other three, a flattened spine.

MEASUREMENTS:

	Female	Male
Length of body	0.714 mm.	0.586 mm.
Length of leg I	0.560 mm.	0.510 mm.
Length of leg II	0.740 mm.	0.688 mm.
Length of leg III	0.668 mm.	0.668 mm.
Length of leg IV	0.770 mm.	0.745 mm.
Palpus	0.306 mm.	0.265 mm.
Mandible	0.178 mm.	0.153 mm.

Types in the author's collection; co-types have been deposited in the collection of the Zoological Laboratory, University of Nebraska, in the Museum of Comparative Zoology, of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

Atax abnormipes was collected at Lake St. Clair during the summer of 1893, but owing to confusion of different species due to lack of familiarity with the group, no statement can be made as to the hosts except that it was almost surely harbored by *Unio alatus*, *U. ventricosus* and *U. luteolus*. It was next met with at Grand Rapids, Mich., in the summer of 1895, when individuals were found in *U. ligamentinus*, *U. occidens*, *U. ventricosus* (very abundant), *U. alatus* and *U. rectus* from different localities in Grand River, while collections made since have added to the list of hosts *U. undulatus*, and emphasized the fact that it is far more abundant in *U. ventricosus* than in any other species of mussel. One specimen was found in that species from Rogue River, Kent County, Mich., July 5, 1897. It has been taken in limited numbers in *U. luteolus* from Reed's Lake near Grand Rapids, Mich., in the same *Unio* from Long Lake, Kalamazoo, Mich., and in that and *U. ventri-*

Digitized by Google

cosus, from Black Lake, Holland, Mich., while the past summer it was found in *U. luteolus* from White Lake, Muskegon County, Mich.

At Oshkosh, Wis., the species was found during September, 1897, in *U. gracilis* and *U. luteolus* from Lake Winnebago. In Illinois, as determined from specimens received from Prof. H. M. Kelly and Mr. M. Ricker, *A. abnormipes* has been taken from *U. anodontoides*, *U. gracilis* and *U. occidens* collected at Havana. Finally in material received from Mr. R. H. Johnson and obtained at Chautauqua Lake, N. Y., it occurred in *U. luteolus* and *U. phaseolus* and perhaps in *Anodonta plana*, though the record is doubtful, while it also was present in mites taken from *U. ventricosus* at Cheektowaga, Erie County, N. Y.

6. A. INDISTINCTUS WOLCOTT.

Atax indistinctus Wolcott, 98; 281.

The second species of *Atax* referred to under the head of the preceding is *A. indistinctus*, which received the name it bears when only females had been collected, and in reference to the close resemblance between the females of the two species, which were only separated by the most careful observation. Since the preliminary paper in which this was described has been published an abundance of males have been secured and the species shown to be entirely distinct though closely allied.

A. indistinctus is a species rather under medium size and yet a little larger than *A. abnormipes*, the measurement of several males showing a variation in body length of from 0.675 mm. long by 0.55 mm. broad to 0.75 mm. long by 0.618 mm. broad, while the average of a number of females was 0.625 mm. by 0.63 mm. It is similar in form to *A. abnormipes*, and like that species the whole surface of the body is marked off by fine lines into small hexagonal areas.

Eyes large but not quite so large as in the preceding species, and about the same distance apart.

Maxillary shield similar to that of *A. abnormipes*, but the posterior lateral angles not so prominent and the sides in front of it slightly diverging instead of parallel. Rostrum rather prominent.

Mandibles similar to those of *A. abnormipes* in form.

Palpi rather slender but not so much so as in those of the previous species. The spines are similar in number and position to that form, the two on the outer side of 2 dividing it into thirds. The distal margin of this segment is not uniformly concave but a shallow re-entrant angle separates the extensor two-fifths and the flexor three-fifths of its length. A rounded angle in the proximal margin of 3 corresponds to this, the segment being proportionately heavier than in the allied species, while 4 is

Digitized by Google

also proportionately stouter and more tapering, its base being nearly as thick as that of 3, while the distal end is only one-half as thick as the proximal; its breadth in the middle is a little over one-half its length. The papillae on this segment are rather more prominent than in *A. abnormipes*. 5 is similar to that of that species but the claws are more slender and a little farther apart, and the ventral distal angle a little more produced.

Epimera.—Of the same general character as in *A. abnormipes*, but differing in the following respects: They occupy slightly less than a proportionate amount of the ventral surface; the space between the groups of epimera is a little greater and the inner ends of the first pair do not approach closely to each other but leave a considerable interval behind the maxillary shield. This is owing to a shortening of I and is accompanied by an increase in the curvature of the posterior margin of the plate formed by it and II, which margin is also indistinctly angled toward the base of II. The posterior margin of IV does not project so far posteriorly and so the genital field is not to such an extent enclosed by it.

Legs of female relatively longer than in *A. abnormipes* and very slightly more slender. I is one-tenth shorter than the body, II and III about one-fifth longer and of the two, II a trifle the longer, IV two-fifths longer than the body. Individual segments of each leg in order of length 4, 6, 5, 3, 2, 1, except in IV, where the last three are 6, 5, 4. Number and distribution of spines on the legs about the same as in *A. abnormipes*; a row of long spines on the flexor surface of segments 4 and 5 of leg IV; the tip of 5 in each leg armed by several long spines.

In the male, I slightly exceeds the body-length; II, III and IV are each a little over two-fifths longer, and of these IV is slightly longer than II and that slightly longer than III. Segments in I and II, in order of length 4, 6, 5, 2, 3, 1; in III, 5 is longer than 6, and in IV, 6 is less than 2 or 3, this shortening leading to a shortness of the whole leg. The same three spines are present at the distal end of IV 5, but are not so long—not quite two-thirds the length of 6. IV modified in a similar manner to the same in *A. abnormipes*, but differing in the following details: Spines on 3 much more numerous; on the posterior surface of 4 the spines are longer and more numerous, and on the ventro-anterior surface are eight spines, three in a dorsal and five in a ventral row; the distal portion of this segment is not so much compressed, and the ventral surface is quite evenly convex; 5 is thicker, has a row of ventral spines as in *A. abnormipes* but only one long heavy spine in the middle of the dorsal surface instead of two. Claws similar except that the accessory tip is one-third the length from the end of the principal one.

Genital area as in *A. abnormipes* in form except that the angle which separates the plates of the two sides anteriorly is more acute here than in *A. abnormipes*. Acetabula in males usually seven on each side—in one specimen eight—with an indefinite separation into two groups. In the female are three and six on the two plates of either side, in one case four and five on one side and three and six on the other.

Digitized by Google

MEASUREMENTS:

	Male	Female
Length of body	0.740 mm.	0.867 mm.
Width of body (extreme).....	0.637 mm.	———
Length of leg I.....	0.785 mm.	0.698 mm.
Length of leg II.....	1.066 mm,	0.890 mm.
Length of leg III	1.050 mm.	0.870 mm.
Length of leg IV	1.076 mm.	1.020 mm.
Palpus (from another specimen of same size in case of male)	0.347 mm.	0.380 mm. (approx.)

Types in the author's collection; co-types have been deposited in the collection of the Zoological Laboratory, University of Nebraska, in the Museum of Comparative Zoology of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

Specimens of females of this species taken at Lake St. Clair, Mich., were confused with the following species and their identity not detected till mounted and subjected to a careful microscopical examination, when the differences between the two species became apparent. Hence no statement can be made as to the definite source of the specimens.

It was therefore with much pleasure that upon looking over the collection of mites from Prof. H. M. Kelly, this species was found in considerable numbers—60 males and 115 females altogether. They were taken from *U. alatus* and *U. gracilis* from the Illinois River at Havana, Ills.; from *U. gracilis* from the Spoon River at Duncan's Mills and Bernadotte, Ills.; and from "*Unio* spp." from the Cedar River at Mt. Vernon, Iowa. Specimens were also found in the material from Mr. M. Ricker.

7. ATAX SERRATUS WOLCOTT.

Ataxx serratus Wolcott, 98; 282.

Ataxx serratus resembles very closely the two preceding species in the appearance of the palpi and in the form of the claws and to a lesser degree in the outline of the genital field and of the epimera. It is larger, proportionately more elongated and the body of the male is only slightly pyriform. The legs are proportionately shorter and IV of the male is not modified. They are characterized by the presence of numerous serrate spines which suggests the specific name proposed.

The body is oval in form, bluntly and evenly rounded at both ends in the female, that of the male with a slight posterior emargination. Its

Digitized by Google

extreme width at a point a short distance beyond the middle is equal to two-thirds of the length; from the side the dorsal convexity is seen to be considerable and quite uniform, but highest posteriorly. Its surface is smooth and without chitinous thickenings or lines of any kind, though the epimera show the regular reticulation referred to in regard to the two preceding species.

Eyes as in the two preceding forms, large and deep black in color, though a little farther apart than in the others.

Maxillary shield similar to that of the preceding; suture between the two plates running about half way forward from the posterior end and a little farther than even with the posterior lateral angles.

Mandibles.—Ventral margin nearly straight; dorsal parallel to it, curving outwardly however toward the posterior end, and this curve continued evenly around the posterior end to the produced posterior ventral angle. Distal joint medium in size and not noteworthy as to form; claw slightly curved, and concave margin slightly arched outwardly in middle.

Palpi large and heavy, similar to those of the preceding in form. Convex dorsal margin of 2, two and a half times the length of the nearly straight flexor margin and 2 one-third as broad as the length of the whole palpus; there are two spines near the middle of its outer surface, one on the inner near the middle and another near the distal margin which is flat, blade-like and serrate. 3 very broad, its breadth four-fifths that of the preceding and one-half its length; inner margin one-half of outer and both nearly straight. 4 thick, considerably tapering, at the base two-thirds as broad as 2 and at the tip less than one-fourth as broad. Paired papillae three-fourths the distance to the distal end. 5 has the inferior distal angle produced and a spine at the base of the projection on the outer side.

Epimera occupying two-thirds of the ventral surface, with the spaces between the groups narrow; the inner ends of the anterior groups approach each other much closer than in the preceding, and the posterior margin, instead of being smoothly rounded, shows an excavation opposite the junction of the two epimera. Anterior median angles of posterior groups produced, anterior margin concave; the inner margins diverging posteriorly; the posterior median angles rounded off; and the posterior margin convex, but only moderately so. Suture separating III and IV nearly complete.

Legs moderately heavy, rather more slender than in the other two species and proportionately shorter, while the species is peculiar in the fact that III is longer than II. In the male I equals about three-fourths the body length, II is somewhat shorter than the body, III about equal to it, while IV, which is shortened, is only one-tenth longer. In the female all the legs are relatively shorter still and IV is scarcely longer than the body. Length of individual segments in order, beginning with the longest, 4, 5, 6, 2, 3, 1, except in III where 5 is about equal to 4 and in IV of both male and female where 5 is greater than 6 and that than 4. In the female more or less of the spines on the legs are serrate along both

Digitized by Google

margins, those on only the basal segment of I, but gradually including more and more on each leg, till on IV are serrate spines on all segments, and on the distal is a row of very prominent, flattened, blade-like, serrate spines. On IV 4 are also three heavy club-shaped spines. In the male serrate spines are present, but less numerous and not so prominent, while the sex is characterized by not only the shortening of the last pair of legs but also by a thickening of the same making them stouter than the two preceding pairs and about as stout as the first. The claws are sharply curved, have an accessory tip at two-thirds the distance from the base, and end in a very fine point.

Genital area broader than long, each lateral plate divided in the female into two, an anterior pouch-shaped plate with its inner end produced into a long neck, curved backward and bearing on its tip a flattened spine, and a posterior nearly circular plate. Three specimens examined possessed the following number of acetabula: 15 and 31 on one side, 12 and 25 on the other; 11 and 21 and 12 and 19; 8 and 12 and 6 and 17. The male has but a single plate on either side with a total of 19 or 20 acetabula on each side.

MEASUREMENTS:

	Male.	Female.
Length of body	0.868 mm.	1.170 mm.
Length of leg I	0.668 mm.	0.816 mm.
Length of leg II	0.820 mm.	1.020 mm.
Length of leg III	0.870 mm.	1.070 mm.
Length of leg IV	0.959 mm.	1.214 mm.
Length of palpus	———	0.510 mm.

Color of legs, a bright blue-green, and body tinged with bluish-green.

Types in the author's collection; co-types have been deposited in the Zoological Department, University of Nebraska, in the Museum of Comparative Zoology of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

Of *A. serratus*, specimens have been collected at L. St. Clair, probably from *Unio luteolus*. At Grand Rapids, Mich., specimens have been obtained from *Unio coccineus*, *U. undulatus* and *U. alatus* from Grand River, and from *Margaritana deltoides* from Rogue River, Kent County, Mich. In material from *Unio occidens* from Cayuga, Cheektowaga, Erie County, N. Y., one specimen was found, while specimens have been secured amongst a number of mites from "*Unio* spp." collected in the Cedar River, Mt. Vernon, Iowa. It is thus a widely distributed species, though one of the rarer ones. Owing to an accidental interchange of the marks "♂" and "♀" upon the labels of two slides and the distraction of numerous interruptions when the preliminary description of this species was

Digitized by Google

written, confusion occurred in that description and so it is in certain particulars wrong. Unfortunately too, and much to the writer's regret, the error was overlooked in the reading of proof and only discovered after the separates were distributed.

8. ATAX FOSSULATUS KOENIKE.

Atax fossulatus, Koenike, 95b; 221, Pl. III, f. 68-70: Wolcott, 98; 283.

A. fossulatus is one of the larger species of the genus, the males ranging in length from 1.1 mm. to 1:3 mm., the females from 1.4 mm. to 1.6 mm. The body is oval, smoothly rounded anteriorly and posteriorly and with the greatest breadth about opposite the posterior margin of the last epimera; dorsally it is considerably arched, somewhat higher posteriad.

The eyes are moderately large and quite close together, in one male specimen 1.08 mm. long, the longest diameter of the eye amounting to 0.046 mm., and the distance between the inner borders of the two to 0.224 mm., while the extreme width of the body is 0.718 mm.

Maxillary shield broad, the sides anteriorly nearly parallel, the latero-posterior angles moderate and the shield contracted posteriorly to a rather broad and short ancoral process the width of which is two-sevenths the greatest width of the shield.

Mandible with basal segment roughly rectangular, broadened posteriorly, the dorsal and posterior margins forming, by the rounding off of the posterior dorsal angle, a sweeping curve. Total length in the specimen referred to above, 0.28 mm. and greatest width somewhat more than half the length. Distal joint moderate in size and with the claw comparatively short and straight, slightly hooked at the tip; the area of cross-striae on the side of the base of the claw comparatively restricted.

Palpi rather large and moderately heavy, in the specimen referred to previously the length amounting to 0.607 mm., while the maximum dorso-ventral diameter of segment 2 is 0.184 mm. Segment 2 is convex on both dorsal and ventral margins, but the dorsal curature is much the greater; it is but little longer than thick, and bears on both outer and inner surfaces two spines, those of the outer side close together midway between the two ends and near the dorsal margin, those on the inner side also close together, slightly farther from the base and more removed from the dorsal margin. 3, about two-thirds as thick as 2, one-half as long, and with a spine at the proximal margin on the inner side and another toward the distal margin on the outer side. 4, slightly longer than 2, slightly less than one-half as thick; the dorsal and ventral margins nearly parallel to the base of the paired papillae on the ventral surface, beyond which the thickness of the segment rapidly diminishes. All segments showing a gradual tapering when viewed from above. The outer of the paired papillae is very small, the inner more prominent and the spur at the distal margin moderately so. 5, nearly straight above, concave below, tapering to a blunt tip, which bears three small blunt claws; on the ventral margin, midway between base and tip, a small hair.

Digitized by Google

Epimera covering approximately the anterior half of the ventral surface of the body, the spaces between the two groups on either side comparatively narrow, that between the groups of opposite sides greater, especially in the case of the anterior groups, between the inner ends of which is quite an interval. The spaces are all wider in the female and in that sex the epimera are relatively a little smaller than in the male. The last epimera are relatively long, being longer than broad, while just external to the inner posterior angle the posterior margin bears a spur-like projection which curves outwardly and probably serves as a point of muscle attachment. III, broadened externally, and an excavation on the outer margin corresponding to the suture between it and IV.

Legs rather long and slender, the first considerably stouter than the others; the first pair of the female nearly three-fourths the body length, II seven-eights of that length, III slightly exceeding the length of the body, and IV nearly a fourth longer. In the male the legs are proportionately still longer, all exceeding the length of the body, I by a very little, IV by over two-thirds. Of the individual segments, 4 exceeds 5 and that 6, except in III, where 5 is longer than 4, and in IV where 5 is still more elongated and 6 greatly lengthened, slightly exceeding 5. The segments gradually decrease in thickness from 1 to 6 and the last tapers constantly from base to tip. The legs are armed with a considerable number of spines of medium length, which form a continuous row along the ventral surface of segments 4 and 5, and also along 6 in the case of IV, the spines in this last case shorter. The distal segment is unusually contracted toward the tip, and is not cleft to receive the claws, but these last are partly covered by a thin chitinous plate, which, together with several slender hairs, springs from the dorsal side of the segment behind the claws. The claws are bifid, a small accessory claw being developed on the dorsal side of the primary one very close to the tip, except in the case of the first leg, where the secondary claw is longer and springs from a point one-third the way back from the tip of the other. The claws, as a whole, are rather heavy and strongly curved.

The genital area is situated about midway between the last epimera and the end of the body, slightly nearer, perhaps, to the latter. It is broadly oval in form and nearly as broad as long. In the male the genital cleft is flanked by two reniform plates, which bear five large acetabula, of which the two anterior are in contact, the second separated by a narrow interval from the third, the three posterior in contact, and the two last situated side by side; several short spines are found along the inner margin of these plates. In the female the five acetabula bear the same relationship to one another but the two plates are not so evident and the acetabula seem to be set into the surface of the body itself, though this is thickened over the whole by a deposition of chitin. At the genital opening, short clefts in this thickened area run toward either side and in the four angles formed by these and the genital cleft itself, are four short, stout, curved spines, while other smaller spines occur here and there, scattered over the space within the row of acetabula and along the margin of the genital cleft.

Digitized by Google

MEASUREMENTS:

	Male	Female
Length of body	1.186 mm.	1.419 mm.
Length of leg I	1.188 mm.	1.035 mm.
Length of leg II	1.515 mm.	1.285 mm.
Length of leg III	1.647 mm.	1.438 mm.
Length of leg IV	1.958 mm.	1.739 mm.

This species was the most abundant of all at Lake St. Clair, 228 specimens being secured from a number of species of Unionidæ, but no definite statement of the exact species in which it was taken can be given, except that among them were *U. alatus*, *U. ventricosus* and *U. luteolus*.

Specimens were secured at Charlevoix, Mich., and vicinity, as follows: in Round Lake, from *Anod. subcylindracea*, *A. footiana* and *U. luteolus*; in "26" and Twin Lakes from the same Anodontas and *A. edentula* and *A. fragilis*; in South Lake, Beaver Island, Lake Michigan, from *U. luteolus*. Nowhere else has this species been found in Anodontas, and I should be tempted to believe that those collected had migrated from *Unio luteolus* while the mussels were kept in pails of water a day or two before being examined, were it not that at Twin Lake only Anodontas were collected. The species was rare at all of these localities.

At Grand Rapids, Mich., *A. fossulatus* has been found very generally distributed,—in *Unio luteolus* at Reed's Lake; in *U. rubiginosus*, *U. plicatus*, *U. undulatus*, *U. pustulatus*, *U. Novi-eboraci*, *U. occidens*, *U. ventricosus*, *U. ligamentinus*, *U. spatulatus*, *U. rectus*, *U. coccineus*, *U. verrucosus* (especially abundant), *U. alatus*, *U. Schoolcrafti*, from different localities in Grand River; and in *U. occidens* from Rogue River, Kent County.

The species has also been taken at Lansing, Mich., but from what host is uncertain. At White Lake, Muskegon County, it was found the past summer in *U. luteolus*, and at Black Lake, Holland, Mich., it has been collected from that species and from *Unio occidens*.

At Oshkosh, Wis., it has been found in *Unio gracilis* and *U. luteolus*.

Digitized by Google

It is present in the material from Illinois in *U. alatus*, *U. asperrimus*, *U. cornutus*, *U. gracilis*, *U. pustulosus*, *U. plicatus* and *U. occidens* from the Illinois river at Havana, and from *U. gracilis*, *U. levissimus*, *U. lachrymosus*, *U. pustulosus* and *U. tuberculatus* from the Spoon River at Duncan's Mills and Bernadotte. Also in material from the Cedar River at Mt. Vernon, Iowa, from *U. rectus*, *U. alatus* and others.

In New York it has been found at Chautauqua Lake in *U. luteolus* and at Cheektowaga, Erie County, in *U. occidens*.

9. Atax stricta Wolcott.

Atax stricta Wolcott, 98, 283.

Very similar to the preceding in many ways but differing in details. It is smaller than *A. fossulatus*, relatively broader and the legs are not only slenderer and shorter, but have usually a blue tinge which is lacking in the other species.

Eyes small and rather distant from one another.

Maxillary shield and mandibles very similar to those of *A. fossulatus*.

Palpi slenderer than those of that species and with the last segment somewhat more strongly curved; ventral papillae on 4 relatively a little more prominent.

Epimera in general of the same form. They are, however, slightly broader proportionately, and the posterior median angle of IV is more rounded and not so strongly excavated.

Legs relatively shorter, more slender and not so tapering as those of the preceding species. I, not so noticeably stouter than the others and distal segment, instead of growing constantly smaller toward the tip, is narrowed in the middle and dilated at the tip, which is even slightly broader than the base. As in *A. fossulatus*, 5 is relatively elongated on III and both 5 and 6 on the last pair of legs, and as in that species III is longer than II. Distal segments relatively longer on all legs and last segment flattened and very slightly dilated dorso-ventrally at the tip, instead of gradually contracted as in *A. fossulatus*. Claws all simple, relatively longer and more slender, and those on I stouter and not so evenly curved as those of the other legs. Not so many spines on the legs as in the allied form, but they are longer.

Genital area in about the same position as in the preceding but relatively smaller, the acetabula smaller, and intead of the last two being side by side they are all in one curved line. The two rows do not approach each other so closely anteriorly and posteriorly as in the other species. The sexes differ in a manner similar to those of *A. fossulatus*.

Digitized by Google

MEASUREMENTS OF A MALE:

Length of body	0.835 mm.
Length of leg I	0.811 mm.
Length of leg II	0.995 mm.
Length of leg III	1.107 mm.
Length of leg IV	1.250 mm.

No female is in such a condition on the slide as to allow of ready or accurate measurement.

Types in the author's collection; co-types have been deposited in the Museum of Comparative Zoology of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

This species when collected was considered to be the male of *A. fossulatus*, but when slide-mounts of that species were made the true male was discovered, and also both sexes of the present form. The most striking difference, and that first noted, was in the position of the acetabula in one line, hence the name "*stricta*," but careful observation showed the presence of other differences as above indicated and also that these differences, though slight, were constant. It may be a variety of *A. fossulatus*, but it is for the present considered separate, though closely allied.

Specimens were taken at Grand Rapids, Mich., during the summer of 1895, among *A. fossulatus*, from *U. coccineus*, *U. ligamentinus*, *U. occidens*, *U. rectus*, *U. rubiginosus*, *U. Schoolcrafti*, *U. undulatus*, *U. verrucosus* and *U. alatus*—89 specimens altogether—but owing to their being confused with *A. fossulatus* no statement can be made as to the exact source. Collections of many more of the same mussels from near the same localities, this last summer, it was hoped would give more definite information, but only one specimen was found, which was in *U. undulatus*.

In Nebraska it has been collected from *U. Jamesianus* and *U. lachrymosus* from pools near Lincoln, from *U. undulatus*, *U. lachrymosus*, *U. rubiginosus* and *U. Jamesianus* at Weeping Water, from Weeping Water Creek; and from *U. lachrymosus* from the Blue River at Milford. The Nebraska specimens are all peculiar in that the genital area is a little smaller and the

Digitized by Google

acetabula smaller and more closely crowded toward the middle of either side.

Specimens were received from Prof. Kelly and Mr. Ricker collected in *U. plicatus* at Havana, Ills.

10. ATAX ARCUATA WOLCOTT.

Atax arcuata Wolcott, 98; 284.

A species equal in size to *A. fossulatvs* and *A. ypsilophorus*, between which it appears to occupy an intermediate position, having resemblances to both, but quite distinct from either. It is especially characterized by the form of the legs, the distal segments of which are so strongly curved as to suggest the name bestowed upon it.

It is of the same elongated elliptical form which characterizes the related species, very slightly broader posteriorly, and with both anterior and posterior margins evenly rounded.

Eyes very small and lenses nearly equal. In the male specimen measured the two were 0.301 mm. apart.

Maxillary shield similar to that of *A. ypsilophorus*, except that the ancoral process is not so long, and the lateral margins perhaps a little less divergent anteriorly.

Mandibles of the same form as in that species except that a concavity is present in the posterior margin toward the ventral angle, whereas in *A. ypsilophorus* the margin is nearly straight.

Palpi also very similar to those of *A. ypsilophorus*, though varying somewhat in the direction of those of *A. fossulatus*. 1, as heavy as in the former species, but 3 relatively less thick, and 4, instead of tapering, nearly as thick at its distal as at its proximal end, the ventral papillae being more prominent. Distal segment slenderer and longer than in *A. ypsilophorus* and the claws at the tip relatively smaller.

Epimera.—Anterior groups narrower toward the median line and more nearly triangular than in either *A. ypsilophorus* or *A. fossulatus*. Posterior group much shorter than in either and inner margin distinctly shorter than the outer, with both anterior and posterior inner angles very much rounded, especially the latter, which causes the epimera of the two sides to appear widely divergent posteriorly. Space between the two groups of epimera on each side very wide.

Legs very long, especially in the male, and similar to those of *A. fossulatus* in that I is very markedly thicker than the rest and in that the successive segments of each leg are distinctly slenderer than the one next the body and give an evident tapering appearance. They are, however, relatively slender. III is a trifle longer than II, all but I exceed the body in length, and IV is over half as long again. Of the segments, 5 is in all legs unusually long and 6 abnormally short. The legs are less plentifully supplied with spines than are those of either of the other two species and the spines are rather weak. The legs are especially characterized by the curved form of the terminal segment, the curvature being only moderate in the case of I, but in IV amounting to a deflection of 80°. This

Digitized by Google

segment also tapers toward the tip but just at the end is broadly expanded to receive the short thick bifid claw, which is much smaller, broader and thicker than in *A. fossulatus*. The rounded margin of the expanded tip of the segment projects above the claw beyond its base, and bears two short flattened lanceolate spines which project still farther.

Genital field similar in form to that of *A. ypsilophorus* though somewhat broader, being broader than long, like that of that species in position, and finally also flanked in both sexes by a single plate on either side, which bears in the male about 22 to 25 acetabula, in the female 26 to 30. These are not all of the same size and two a little before the middle and against the outer margin of the plate are decidedly larger than the rest. Spines at the genital opening of the female similar to those of *A. ypsilophorus*, heavy, curved and flattened. A few small and weak spines are seen along the inner margin of each genital plate.

MEASUREMENTS:

	Female	Male
Length of body	1.170 mm.	1.250 mm.
Length of leg I	0.918 mm.	0.872 mm.
Length of leg II	1.413 mm.	1.346 mm.
Length of leg III	1.454 mm.	1.382 mm.
Length of leg IV	2.040 mm.	1.907 mm.
Length of palpus	0.403 mm.	0.408 mm.
Length of genital field	———	0.224 mm.
Width of genital field	———	0.255 mm.

In color this species is not distinguishable from *A. ypsilophorus*.

Types in the author's collection; co-types have been deposited in the collection of the Zoological Laboratory, University of Nebraska, in the Museum of Comparative Zoology of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

A. arcuata was first found at Charlevoix, Mich., in Round Lake and living in *Anodonta subcylindracea*, *A. footiana* and *Unio luteolus*. At "26" Lake it was collected in *Unio luteolus* and at Intermediate Lake in *Margaritana rugosa*, *A. subcylindracea*, *A. footiana*, *A. edentula* and *A. fragilis*.

At Grand Rapids, Mich., it has been taken in *Marg. deltoides*, *M. marginata* and *A. subcylindracea*, and at Rogue River, Kent County, in *A. subcylindracea*. At White Lake, Muskegon County, Mich., it has also been found common in *A. subcylindracea* and in all the collections referred to, far more specimens were taken in that than in any other mussel.

It has been collected in *Marg. marginata* from the Schuylkill River at Phœnixville, Pa., and specimens were received from Prof. Kelly.

Digitized by Google

11. ATAX YPSILOPHORUS (BONZ).

Acarus ypsilophorus Bonz, 1783; VII, 52, Pl. I, f. 1-4.

Trombidium notatum Rathke, 1797; IV, 175, Pl. X.

? *Hydrachna triangularis* Say, 21; II, 79: id., Leconte's Ed., 59; II, 22.

Limnochares anodontae Pfeiffer, 24; pt. 2, 27-28, Pl. I.

Hydrachna concharum von Baer, 27; XIII, 590, Pl. XXIX.

Unionicola oviformis, *U. lactea*, ? *U. personata*, ? *U. humerosa*, ? *U. symmetrica*, ? *U. proxima*, ? *U. lugubris*, ? *U. unicolor*, ? *U. reticulata*—Haldeman, 42; 1-3, Pl., f. 1-11.

Non *Atax ypsilophora* von Beneden, 48; (=*A. intermedius* Koenike).

Atax ypsilophora Garner, 64; 114: Claparède, 68; 474, Pl. XXXIII: Bessels, 69; 146: Lebert, 79; 367.

Atax ypsilophorus Neuman, 80; 26, Pl. I, f. 2: Koenike, 87a; 626: Haller, 81a; 78: Koenike, 82; 265: Leidy, 83; 44: Harrington, Fletcher and Tyrrell, 84; 140.

Atax concharum Krendowsky, 85; 59.

Atax ypsilophorus Barrois and Moniez, 87; 5: Girod, 89; XIV, n. 5, 107: Koenike, 91c; 257: Piersig, 94b; 214: Koenike, 95b; 217: Piersig, 96; 40: Koenike, 96; 232: Piersig, 97; Lief. I, 43. Pl. II, f. 3, a–h.

This, the best known of all the species of the genus and the one first described, is also one of its larger representatives, the males measuring from 1.1 to 1.3 mm. in length, the females from 1.3 to 1.5 mm., or when distended with eggs, 1.8 mm. The body is oval, but more nearly elliptical than in most species, evenly rounded at each end, and much arched. The males are considerably slenderer than the females.

The eyes are proportionately small and moderately close together, in a specimen 1.086 mm. long, 0.296 mm. apart. They are brownish black in color.

The maxillary shield is widest anteriorly, quite evenly rounded posteriorly and with a prominent ancoral process, which is considerably broadened at the tip, each lateral corner of which is produced to form a recurved hook. The rostrum is moderately prominent. Mandibles relatively short and broad. in a specimen 1.32 mm. long, their total length being 0.24 mm. The basal segment is broadest posteriorly, where its width is over two-fifths the total length; its ventral side is nearly straight, with the posterior angle produced; its dorsal and posterior side form together a sweeping curve from near the anterior end on the dorsal side to the ventral posterior angle. The distal joint is rather heavy, but the claw is deeply inserted and the exposed portion is relatively short and slender, and quite straight. The area of oblique striae is rhombic in outline and confined to the base of the claw, which is bent at a point even with the distal margin of the segment, and ends in a sharp point.

Palpi.—Comparatively small and only moderately thick. The first segment is narrow, and 2 is wide, being twice as wide as 1, and wider than long, measured from the middle of one end to the middle of the other. Ventral margin slightly convex, the dorsal strongly so 3, short and moderately broad with both sides nearly straight, while 4 is of moderate length,

Digitized by Google

somewhat longer than 2, gradually tapering and with sides nearly straight. The paired papillae on its ventral surface are a little over two-thirds the way toward the tip and the claw at the distal margin is only moderately conspicuous. 5 is rather small, curved, with the ventral side unusually concave and the tip slightly broadened and bearing the usual claws, which are here rather prominent. The inner side of 2 bears a spine near the middle, and the outer side two in the middle and nearer the dorsal margin; 3 has a spine at the basal margin on the inner side and one at the distal margin on the outer; 4 has in addition to the hairs on the papillae, two small ones on either side of the claw at the distal margin of the ventral surface; and 5 has a hair on the outer side a short distance from the base. Piersig (97) describes the hairs on the outer side of 2 as feathered but I can discover no such on my specimens.

The epimera are quite typical. The anterior groups are quadrilateral and the posterior rectangular with the spaces between them of considerable width, especially in the female, in which sex the posterior groups are relatively shorter. The anterior groups have the anterior and posterior margins nearly equal, the outer a little shorter and the inner still shorter. I is nearly of equal breadth throughout and its inner end makes up the whole of the inner margin; II is triangular with both anterior and posterior margins convex; while its inner end is prolonged into a short curved hook which turns backward and outward. III makes up only one-fourth of the length of the posterior group, which has a slightly concave anterior margin, a nearly straight inner margin, a convex posterior margin, and rounded angles.

The legs are of medium length, and rather slender, with the first pair not much thicker than the rest. I in the female is nearly five-sixths of the length of the body, II is about one-seventh longer than the body, III is shorter than II and about equal to the length of the body, while IV is more than a half longer than the body. In the male the legs are relatively somewhat longer. Of the individual segments, 4 is longest and the others follow in the order 5, 6, 3, 2, 1, except in IV where 5 is longest, and it and 6 both exceed 4. All the legs are abundantly supplied with hairs and spines, and many of them, especially on the middle segments of the anterior three legs and at the tip of IV 5 are long and almost like swimming hairs. IV has the ventral surface of 4 and 5 thickly beset with spines of moderately length, and this pair of legs has, on the whole, more spines, but they are shorter than in the preceding pairs. The distal end of segment 6 on all the legs is broadened dorso-ventrally and receives in a groove in it the thus retractile claw. The claws possess two tips of which the proxinal one is slightly curved and meets the distal tip which is in line with the basal portion of the claw, at a right angle. The distal tip curves slightly for a short distance beyond the junction of the two, and then turns sharply ventrad so that its outer end is nearly parallel to the proximal tip.

Genital area flanked by two plates, each of which bears from 16 to 24 acetabula. The area in both sexes broader than long, each plate in the female with a thickened strip running from the groove at the genital

Digitized by Google

opening outward toward the acetabula, but not reaching them. The two plates in the male bear a few small spines and the margins next the groove are not thickened or produced. But in the female, these margins are thick, and produced outwardly in front of the genital opening to form two wide lips, which diverge at their tips. These lips each bear along their margins several spines, a small one anteriorly and two or three longer, stouter and somewhat curved ones about the middle. Behind the genital opening the lips are not so prominent and there is but a single longer and more slender spine.

MEASUREMENTS OF A FEMALE:

	Female
Length of body	1.836 mm.
Length of leg I	1.030 mm.
Length of leg II	1.515 mm.
Length of leg III	1.826 mm.
Length of leg IV	2.147 mm.
Palpus	0.495 mm.

The number of previous records of the occurrence of this species in North America is such as to show it a very common and widely distributed form. Dana and Whelpley (36) found it at New Haven, Ct., in *A. fluviatilis* Dillw, and in a second species of mussel which they incorrectly identified as *Unio purpuratus* Lam. Haldeman (42) seems to have collected it in *A. fluviatilis*, *U. radiatus* and *U. cariosus* from the Susquehanna River, Pa. Leidy (83) records it in *A. fluviatilis* from Clarksboro, N. J., and Koenike (95b) from Canada, in *Anodonta fragilis*.

It was found to be common in the summer of 1893 at Lake St. Clair, in *A. ovata*, and also at Lansing, Mich., in the fall of the same year though in what mussels is uncertain.

In Northern Michigan it was equally abundant the next summer, being collected in *A. subcylindracea* and *A. footiana* from Round Lake at Charlevoix; from the same and also from *A. edentula* and *A. fragilis*, from "26" and Twin Lakes in the vicinity of Charlevoix; and in *A. subcylindracea* and *A. fragilis* from Intermediate Lake at Ellsworth, Mich.

At Grand Rapids, Mich., it is abundant and has been collected in numerous localities along Grand River, in *U. pressus*, *M. marginata*, *M. rugosa*, *A. edentula*, *A. ovata*, *A. subcylindracea* and *A. footiana*; from Reed's Lake in *A. fragilis*; from Rogue River, Kent County, in *M. rugosa*, *A. ovata* and *A.*

Digitized by Google

footiana; from Plaster Creek in *A. ovata*; and from the mill pond at Mill Creek in *A. plana* and *U. pressus*.

At White Lake, Muskegon County, Mich., it was collected during the past season in *A. subgibbosa*, *A. subcylindacea*, *A. footiana* and *M. complanata*.

In Illinois, it has been found in *A. corpulenta* and *A. imbecilis* from the Illinois river at Havana and in *A. suborbiculata* from Thompson's Lake near Havana. In Iowa it has been obtained in the Cedar River from *M. rugosa* at Mt. Vernon. In Nebraska the writer has collected it in *U. subrostratus* and *A. grandis* from pools near Lincoln; in *M. complanata*, *A. plana* and *A. decora* from Weeping Water Creek, Weeping Water; and in *A. grandis*, *A. plana* and *M. complanata* from the Blue River at Milford.

From the material received from Chautauqua Lake, N. Y., it is apparently as common as in all other localities cited, and has been collected in *A. plana* and *A. edentula*.

The record of collections shows that it is essentially an *Anodonta* parasite, though occuring in *Margaritana* and rarely in *Unio*.

12. ATAX TUMIDUS WOLCOTT.

Atax tumidus Wolcott, 98; 285.

Very similar to *A.* (*N.*) *ingens* in form and in size, the females of both showing a tendency to enormous distension when filled with eggs, in the relative length of the legs, and also in color, the internal structure of each as a rule giving no suggestion of the usual Y-shaped mark, but the color being a light brown with numerous fine white vermiculate lines, though specimens of *A. tumidus* have been found showing quite a well defined Y-mark. It was stated in the preliminary description of the species that it also agreed in the manner of depositing eggs, but the possibility of an error in this statement was changed to a probability by careful observations on this point during the past summer.

The species is, under normal conditions, one of the largest of the genus, the females measuring from 1.4 to 1.5 mm. in length and when filled with eggs even 1.8 or 2.0 mm., the males ranging from 1.10 to 1.25 mm. The body is oval, broadened posteriorly, evenly rounded at both ends and uniformly arched, being also highest posteriorly.

Eyes small, black, and separated from each other by a considerable distance.

Maxillary shield similar to that of *A.* (*N.*) *ingens*, short and broad, with no ancoral process produced posteriorly, and with muscles attached to long curved processes projecting from the sides backward and upward.

Digitized by Google

Mandibles like those of *A. arcuata* and *A. ypsilophorus* with the line separating the two portions carried backward on the ventral side toward the base, thus causing the distal to encroach on the basal portion. But here the encroachment is greater than in the other cases and the heavy claw seems actually to spring from the side of the distal end of the basal portion.

Palpi comparatively stout, segment 4 especially noteworthy in that regard. The basal three segments are moderately thick but 4 is unusually so, being through most of its length nearly as thick as 3, though narrowed somewhat before the papillae on the ventral surface is reached and from that point diminishing rapidly in diameter till at the tip it is only one-half as thick as at the base. This segment is also short, being not twice as long as 3 and its length only a little more than one-fifth greater than its diameter toward its base. The paired papillae are very short while the third at the tip is quite rudimentary. Last segment rather long, strongly curved and blunt. Claws at the tip very small and inconspicuous.

Epimera resembling closely those of *A. arcuata* but relatively even smaller.

Legs also resembling those of *A. arcuata* in general form but relatively heavier and differing in the fact that II is longer than III by about one-tenth. The swollen body of the present species is also longer in proportion to the length of the legs and only the last pair exceeds it in the male, while in the female none equal it, IV being a trifle shorter. The proportion between the segments resembles those in *A. arcuata*, as regards the relative length of 4 and 5 and the shortness of 6. The distal segment is relatively stouter, and only slightly arcuate. The claws are characteristic, being short and thick with two hooks, the ventral of which is the heavier and somewhat the longer; it projects ventrally at a right angle to the base of the claw and the dorsal hook after continuing for a short distance in line with the base, also turns ventrad at a right angle. The tip of the segment is expanded and has two flattened leaf-like spines dorsally at the distal end which project beyond the claw.

Genital area.—Similar to that of *A. arcuata* in general form but absolutely larger and relatively broader; number of acetabula greater, in the male 34 to 35, in the female 40 to 41. In the male they cover most of the lateral plates which are reniform in shape, in the female while they reach the inner margin posteriorly, they leave about one-half the width bare anteriorly; two lying against the outer margin exceed the others in size, as is the case in *A. arcuata*. The inner margin of each plate is prolonged into a long, flat pointed spine of which the anterior margin is convex, the posterior nearly straight, so that it is shaped something like a beak. Its width at the base is equal to one-fourth the length of the inner margin of the plate and it occupies the second fourth of the margin from the anterior end. The genital plates are thick and the margins very heavy, making a pronounced and quite broad border.

Digitized by Google

MEASUREMENTS:

	Male	Female
Length of body	1.170 mm.	1.660 mm.
Length of leg I	0.724 mm.	0.949 mm.
Length of leg II	0.994 mm,	1.372 mm.
Length of leg III	0.938 mm.	1.255 mm.
Length of leg IV	1.397 mm.	1.612 mm.
Length of palpus	0.331 mm.	0.372 mm.
Length of genital area	0.255 mm.	———
Width of genital area	0.321 mm.	———

Types in the author's collection; co-types have been deposited in collection of the Zoological Laboratory, University of Nebraska, in Museum of Comparative Zoology of Harvard University, in the Uni States National Museum, and in the Kgl. Museum für Naturkunde Berlin.

Atax tumidus was taken at Lake St. Clair in the summer 1893, but only once, in *Margaritana deltoides*. At A Arbor, Mich., three specimens were found in the collection the Zoological Department of the University of Michig from the Huron River, but no record had been made of species of mussel. Two were collected at Lansing, Mic but in what species of Unionidæ is uncertain.

It was only collected in North Michigan in Intermedi Lake at Ellsworth, August 9, 1894, from *Anodonta frag* and *A. edentula*—7 specimens being secured.

At Grand Rapids, Mich., it has been collected in *Anodo subcylindracea* and *Unio undulatus* (once) from Grand Riv in *Anodonta ovata* (?) from Plaster Creek; and in *Anodo subcylindracea* from the mill-pond at Mill Creek, near Gra Rapids.

It thus has been taken only in Michigan and there rarely, yet seems generally distributed through the state also seems to be restricted to *Margaritana* and *Anodonta*, has proven most abundant in *A. subcylindracea*.

13. ATAX (NAJADICOLA) INGENS (KOENIKE).

Atax ingens Koenike, 95b; 219, Pl. III, f. 65 to 67.

Najadicola ingens Piersig, 97; 60.

A. (*N.*) *ingens* is the largest of all our parasitic mites, especially i consider the size of the gravid females, one of which has been measuring 6.0 mm., though the average length of the females i to 2.50 mm., and the males from 1.50 to 1.65 mm. The bod oval, evenly rounded at both ends, and much arched, highes

Digitized by Google

When filled with ripe eggs the female resembles a large swollen sac, with a cluster of short legs at one, and the more pointed end, which when the mite is in a dish, are quite incapable of serving for support or locomotion and the animal lies helplessly on its back, unable to stir until some object which it can grasp is brought within reach, when its attempts to right itself and to escape from its uncomfortable situation are extremely laborious and in cases of great distension of the body, even utterly vain.

It possesses a different style of coloring from all other species except in the case of some specimens of *A. tumidus*, there being no Y-shaped lighter mark upon the back, but the whole body being of a honey-yellow color, deepening to a yellowish-brown on the back, with numerous and irregularly distributed fine white vermiculate lines.

The eyes are reddish-brown, small and rather widely separated. The maxillary shield is short and broad, and quite evenly rounded posteriorly, though on either side of the median line at the posterior extremity there is a small bulging of the outline due to a thickening of the margin of the shield. On each postero-lateral margin a little behind the middle is a curved chitinous process which runs laterally beneath the first epimeron.

The mandible is long and slender with an extreme breadth of a little over one-fifth the total length. It is thin and delicate, especially at the ventro-posterior angle where it is produced backward to a distance equal to one third the total length, forming a rectangular plate which is hollowed, producing a shallow mandibular furrow. The diameter of the basal joint is greatest just anterior to the posterior dorsal angle and grows gradually less till at the junction of the distal joint it is only about half as great. The distal joint is relatively small, with a claw which is broad, curved, indistinctly angled near the base, and sharply pointed. At the dorsal side of this claw is a thin flattened tapering chitinous process.

The palpi are moderately heavy and relatively short, averaging only about one-third the length of the body. The first segment is unusually long and much broader at its basal than at its distal end, which is not true of 2, the distal margin of which is twice the breadth of the basal. The ventral margin of 2 is straight, the dorsal moderately convex; on the inner side are four spines, one near the middle at the dorsal side, a second a short distance ventrad and posteriad of this, and two others distad of the second, forming with it a row running to the middle of the distal margin. On the outer side of this segment a little proximad of the middle and toward the dorsal side are five small spines, enclosing an area which is a nearly regular pentagon. 3 is stout, its ventral margin nearly straight and more than half the slightly convex dorsal margin, and with a small spine on the inner side near the proximal margin. 4 is rather clumsy, nearly as thick at the distal as at the basal end, and bears two very inconspicuous papillae near the distal margin, and a small spur at the margin, on the ventral side. There is also a short, thick, blade-like spine on the inner side at the distal margin, and 5 has the usual three claws at the blunt tip. The palpi thus possess the general characters of those of other species of *Atax*, being peculiar in the number of spines on 2 and the one on the inner surface of 4.

Digitized by Google

The epimera cover only about one-third the whole ventral surface. The two groups of each side leave but a narrow interval between them, but the space between those of opposite sides is wider, especially in the case of the anterior pair. The epimera of the male are relatively larger and closer together than in the female. I and II form a roughly triangular plate with a rounded inner angle, and from the inner end of the posterior margin of II a short, stout, curved process runs back beneath III. Of the plate formed by III and IV, III furnishes about one-third. This plate is longest externally, narrowed toward the median line and the inner end is rounded. All epimera are relatively thick.

Legs relatively short and stout, and the first pair slightly heavier than the rest. In females not distended with eggs and in males the first leg is a little over one-half the body length, II is a little longer than I, III is longer still and over three-fifths the length of the body, and IV is longest but still less than the body-length. The proportions seem to be about the same in the two sexes. Of the individual segments, 5 is in all legs the longest, 6 about equal to it except in IV where 5 is slightly lengthened, and 4 next in length. The distal segments are nearly as thick as the proximal which gives the legs a rather clumsy appearance. Spines are comparatively very few and all short and stout; aside from this they are peculiar only in the fact that each segment except 1 and 6, bears at the distal end, a group of from four to six of these short, stout spines. The claw is received in the end of 6 in a manner similar to that found in *A. ypsilophorus* and the distal end of the segment is slightly expanded. The claw is long, slender, strongly curved and slightly angled at two-thirds the distance from the base, in the case of all but the first leg. In the case of I, the claw is stouter, shorter and evenly curved, but like all the rest simple and sharply pointed.

Genital area not at the end of the body but close behind the last epimera and so produced toward either side that the total breadth is about the same as the distance between the outer margins of the posterior groups of epimera, and approximately two-thirds the width of the body. Each plate has an outline roughly that of a right-angled triangle, the base of which corresponds to the anterior margin, the hypotenuse to the posterior margin, while the short inner margin represents the altitude. The latter margin lies at a short distance from the genital cleft in the female, but in the male bounds it, and meeting the plate of the opposite side in front and behind, surrounds it. The anterior margin is nearly straight, the posterior slightly convex and the outer end rounded. The acetabula are numerous and vary in size, two toward the outer end of each plate being larger than any of the rest.

MEASUREMENTS:

	Male	Female
Length of body	1.503 mm.	2 330 mm.
Length of leg I	0.826 mm.	1.264 mm.
Length of leg II	0.862 mm.	1.346 mm.
Length of leg III	0.943 mm.	1.581 mm.
Length of leg IV	1.367 mm.	2.017 mm.
Length of palpus	0.469 mm.	0.821 mm.

Digitized by Google

This species was first identified from a specimen collected at "26" Lake, near Charlevoix, Mich., from *Anodonta fragilis*, and another collected at Intermediate Lake, Ellsworth, Mich., also from *A. fragilis*. Koenike described it from that species and from *Unio complanatus*.

It seems to be found in both *Unio* and *Anodonta*, as at Grand Rapids, Mich., it has been collected in *Unio gibbosus*, *U. ligamentinus* and *Anodonta footiana*. In one specimen of *A. footiana* were 23 irregular masses of eggs, varying from 1.0 to 2.5 mm. in diameter, and in various stages of development, with one mite 2.0 mm. long and another, a female full of eggs, 6.0 mm. in length. At Long Lake, Kalamazoo, Mich., one male has been taken from *U. luteolus*. Only 16 specimens have been found altogether, so it seems, like *A. tumidus*, to be a rare species.

SYNOPSIS OF THE SPECIES INCLUDED ABOVE.

1. Genital field toward the end of the body and in general form more or less broadly oval or approximately circular; females with variously modified spines about the genital opening which assist in oviposition, the eggs being deposited singly in the gills, (ATAX)..... 2.

   Genital field removed from the end of the body, immediately behind the last epimera and plates so extended transversely as to have the form of very low broad triangles, whose long bases extend from either side of the genital cleft a considerable part of the way toward the side of the body. No spines at genital opening, the eggs being laid in masses between the gills (NAJADICOLA)..... 13 *A.* (*N.*) *ingens* (Koen.)

2. Acetabula 6 on each side in two groups of three each..... 3.

Digitized by Google

Acetabula 5 on each side..... 4.
Acetabula more than 6 on each side..... 10.

3. First pair of legs thicker than the palpi, with movable spines set into the sides of deeply excavated conical papillae, and with claws simply bifid..... 1. *A. crassipes* (Müll.)
First pair of legs not so thick as palpi, without movable spines, and with a broadly expanded pectinate claw..... 2. *A. pectinatus* mihi.

4. Legs very long, first pair thicker than palpi; body truncate posteriorly and with a prominent nipple-like papilla at either lateral posterior angle..... 3. *A. aculeatus* Koen.
Legs shorter and first pair not so thick as palpi; body evenly rounded or emarginate behind..... 5.

5. Last pair of legs modified and posterior margin of the body emarginate..... 6.
Last pair of legs not modified and posterior margin of the body rounded..... 7.

6. Modification consisting of a curved fourth segment on last pair of legs. Legs long and slender..... 4. *A. intermedius* Koen., male.
Modification consisting of a thickening of the first four segments of the last pair of legs, and a shortening of the fifth, which bears two heavy spines, while the sixth is long and slender. All legs stouter and thicker..... 5. *A. abnormipes* mihi, male.

7. Genital plate of each side divided into two parts, with two and three acetabula respectively..... 8.
Genital plate on each side not distinctly divided..... 9.

8. Claw with two hooks nearly equal in length, ... 4. *A. intermedius* Koen., female.

Digitized by Google

Claw with a very small accessory tip on the convex side of the principal one.....
..... 5. *A. abnormipes* mihi, female.

9. Last two acetabula placed side by side; claws bifid..... 8. *A. fossulatus* Koen.
Acetabula placed in a continuous line; claws simple..... 9. *A. stricta* mihi.

10. Acetabula about nine on each side. Hind leg of male modified..... 6. *A. indistinctus* mihi.
Acetabula 20 or more on each side..... 11.

11. Distal segment of palpus expanded, quadrate and with two long curved claws. Body slightly emarginate in male, and legs, especially of females, with more or less serrate spines..... 7. *A. serratus* mihi.
Distal segment of palpus slender, curved and ending in a blunt point armed with small claw-like spines. Body not emarginate behind and no serrate spines on the legs. 12.

12. First pair of legs not noticeably thicker than the rest; distal segment of the legs straight, and claws large and with two long equal hooks..... 11. A. *ypsilophorus* (Bonz).
First pair of legs noticeably thicker than the rest and tapering from base to tip; distal segment slender, more or less arcuate and claws small and bifid..... 13.

13. Distal segment of legs decidedly arcuate; fourth segment of palpus tapering from base to apex. Maxillary shield with an ancoral process posteriorly..... 10. *A. arcuata* mihi.
Distal segment of legs slightly arcuate; fourth segment of palpus swollen and nearly uniform in diameter from the base to the paired papillae on the ventral surface. Maxillary shield with no ancoral process posteriorly..... 12. *A. tumidus* mihi.

Digitized by Google

BIOLOGICAL CONSIDERATIONS.

Most of these mites pass all their life stages within the limits of the mussel's shell, moving about over the surface of the mantle; a few, of which *A. crassipes* is an example, remain only till the last stages of development are reached and then leave the shelter of the mussel to pass the remainder of their life swimming freely about in the water. The eggs are deposited singly in the mantle and gills, rarely, as in *A.* (*N.*) *ingens*, in masses between the gills. The spines guarding the genital opening, by being inserted into the surface of the gill, probably assist in oviposition, either by holding the body firmly against the surface of the gill or mantle which is then pierced by the ovipositor, or by themselves piercing the surface, the ovipositor being protruded between them and the eggs deposited, rather more abundantly in the gills apparently, in the case of the *Unio*-dwellers, more numerously in the mantle by the *Anodonta*-parasites. The development of these eggs has been studied by Claparède (68) and others and five stages have been distinguished.

First, the egg stage, in which the embryo is surrounded by a firm outer membrane and a more delicate inner membrane —the "Zwischenhaut" of Claparède (68), the "Dotterhaut" of Kramer (80) or the "Apoderm" of Henking (82). The former, as development proceeds and the embryo increases in size, is ruptured, but the latter increases in size or is capable of distension and remains surrounding the embryo till the young mite is ready to emerge, when it is also burst open and the larva appears. Third, the first larval stage, in which the mite has but three pairs of legs, and which is very short. Fourth, the nymph stage, in which the larval legs are lost and a new set is developed beneath the old larval skin. Fifth, the second larval or sub-imago stage, in which the mite has four pairs of legs but in which it lacks still the perfect development of the sexual apparatus and the relative proportions belonging to the adult, those only being acquired when a final moult of the skin reveals the adult mite. It is not the intention in this paper to go into details as to this process, further than to note that the

Digitized by Google

first two stages are passed in the substance of the gill, and the next apparently in the spaces between the plates of which the gill is composed. This stage is very short and the nymph is soon formed either in the spaces in the gills or outside them in the mucous over their surfaces. In the latter case the nymphs accumulate in the mass of mucous at the exhalent aperature, and the same species of mite has been reared both from nymphs taken from the gills and from those collected in the latter situation. During the second larval stage the mite is very active and moves freely about between mantle and gills. Generation follows generation in the mussel, the only check to the increase in number of mites being afforded by accidental escape or voluntary migration. The latter, as Kramer (91) observes, usually occurs during the second larval period when the body is smaller, the legs longer, and the mites more active than later. When free from the ancestral mussel they no doubt swim here and there or clamber over the bottom with a chance of finding another mussel and effecting a lodgment therein. However, collections made with nets over beds of mussels have never, so far as the author's experience goes, furnished specimens of these migrating mites.

There seems to be no particular time of year when eggs are deposited as they are found throughout the season, but are apparently most numerous in the summer, while during early autumn the adult mites are most abundant. There also seems to be no one time at which the eggs from any one female mite are laid, but in the same shell and with but a single female, and in which other conditions lead to the inference that she laid all the eggs, they are found in various stages of development.

Lodgment is effected probably with different degrees of facility in different species of mussels. The swiftness of the current seems to have little effect in preventing it, if indeed it does not assist. In lakes with practically no current, collections show the following percentage of those infested, no other conditions being regarded, and all collections being made during August of different years:

Digitized by Google

In Lake St. Clair (Anchor Bay), of 251 mussels, 62 pe cent infested.

In Intermediate L., N. Mich., of 52 mussels, 65 per cent infested.

In Reed's Lake, Grand Rapids, Mich., of 96 mussels, 64.5 per cent infested.

While in Grand River, with a rapid current, collections at various points show:

Of 175 mussels, 62.33 per cent infested;
Of 73 mussels, 60.00 per cent infested;
Of 182 mussels, 90.50 per cent infested;
Of 85 mussels, 82.00 per cent infested.

These last two larger percentages were obtained during the past summer, when the percentage of infested mussels was unusually high. Indeed careful observations made during the summer in the attempt to secure more accurate data than had heretofore been obtained, as to the effect of different conditions, were rendered practically of no value from the fact that the percentage of mussels infested was so abnormally high as compared with other seasons that no accurate comparison could be made with former years and other localities. Still further observations are necessary and only general statements can be made in the discussion which follows.

The mussels which are most sensitive, most active in closing their shells, and whose shells close most tightly, seem to be more immune from the presence of parasites than those possessing less of these properties. The following figures have (p. 245) been selected with reference to such species of mussels as have been represented in the collections by a considerable number of specimens and illustrate different types as regards form.

If these *U. occidens* and *U. ventricosus* are thick, the valves meet at a considerable angle and not closely, and they are slower to close upon irritation. *U. gibbosus*, *U. rectus* and *U. nasutus* are long and thin, the valves meet at a small angle and tightly and they are more active. The other forms are intermediate in these respects.

Digitized by Google

Mussel.	Collected previous to 1898.	Per cent infested.	Collected during 1898.	Per cent infested.
Unio occidens *Unio ventricosus*	19	100.00	40	100.00
Unio luteolus	60	70.00	33	85.00
Unio ligamentinus	57	63.00	75	96.00
Unio plicatus *Unio undulatus*	48	64.50	57	84.00
Unio gibbosus *Unio rectus*	46	15.00	36	55.00
Unio nasutus	24	4.00	—	———

This past summer, however, in the case of *U. spatulatus* and *U. Novi-eboraci*, which are very similar in size and form, an apparent exception to the rule was found; for of 46 specimens of *U. spatulatus*, 20, or 43 per cent. were parasitized, while of 24 of the other species collected with *U. spatulatus*, all were infested. *U. spatulatus* has, to be sure, the advantage in the angle at which the shells close and in activity, but hardly sufficient to lead one to infer the above result from simply a comparison of those characters. The mussels represented in the above table were all from Michigan, none from elsewhere being included, in order to avoid any necessity of allowing for a difference of locality. All were collected together along the Grand River at Grand Rapids, except *U. nasutus* which was from Lake St. Clair and *U. luteolus* which represented specimens from Lake St. Clair, Reed's Lake at Grand Rapids, and White Lake, Muskegon County, together with a few from North Michigan Lakes. Comparison of *U. luteolus* from the different localities showed practically a uniform percentage.

As between Anodontas and Unios, of 29 Anodontas taken previous to this year at the same localities as the above mentioned Unios, omitting *U. luteolus*, 17 or 58.5 per cent were infested; of those taken this summer 68 out of 74 or 72 per cent were infested. Anodontas taken with the *U. luteolus* enumerated above, previous to 1898, showed a percentage of 72 per cent or 33 out of 46, and during 1898, of 95.5 per cent or 21 out of 22.

Digitized by Google

The size of the mussel seems to have little effect. No accurate records were made in regard to this fact previous to the past summer and for reasons stated above, these records are of little value in proving or disproving the fact of any connection between size and percentage of mussels infested. Generalizing from experience, in the absence of previous accurately recorded observations, it seems, however, that there is none.

The same is true of sex, which seems to affect in no degree the extent of parasitism, though it might be supposed that especially in the case of a gravid female entrance by the mite might be the more easily effected.

Records kept the past summer also as to depths at which the shell was buried and amount of vegetation on the bottom, furnish no satisfactory data. It has become evident that it is not an easy matter to collect facts in such form as to allow of a proper comparison of the importance of the various factors which determine the occurrence of parasitic mites in various species of Unionidae and under different conditions. And it has also become evident that perfectly accurate statements, with the accumulation of the data necessary to furnish an adequate basis for them, will only be possible after years of careful observation. The author regrets that he has not the benefit of such in the preparation of this paper, but hopes that he may at some time in the not far distant future be able to report more fully upon this exceedingly interesting subject of research.

The maximum number of mites found in a single shell has occurred in the case of an *Anodonta plana* from a pool near Lincoln, Neb., opened in September, 1895. In it were 15 *Atax ypsilophorus* and 406 *A. intermedius*—93 males and 313 females. The mussels collected in Nebraska, however, especially the Anodontas, have averaged more mites to the specimen than those collected in Michigan, though the percentage of those infested is about the same.

The presence of these mites seems to entail few, if any, consequences upon the host; though Garner (64) claims that their

Digitized by Google

presence causes the growth of pearly prominences on the inside of the shell, and it is possible the irritation due to the presence of eggs in the mantle, might in some cases lead to this. The figures collected the past summer are not sufficient to allow of accurate statements being made. When the attempt is made to allow for the effect of age, of variation in form in the different species, and situation as affecting the probability of the entrance of foreign particles, the number of mussels examined does not furnish sufficient data for definite conclusions. Other sources of uncertainty are added when it is considered that even if no mites are found in a mussel of considerable size the assumption that it never has contained any is entirely unwarranted, and when it is remembered that in case of infested mussels we have no means of knowing how long the mites have been there and whether or not sufficient time has elapsed for the demonstration of any effects on the host.

But upon the mites themselves the effect is more pronounced. Living in the gills during development and later in a slimy secretion, as they do, the tracheal system is less perfectly developed, in some cases becoming quite rudimentary. Yet they live for weeks in a vessel of water after removal from the mussel. Here the other effects of parasitism become apparent, especially if we compare free-living and parasitic species. The body of the parasitic forms is large and more or less unwieldy, in the case of the females of *A. tumidus* and *A.* (*N.*) *ingens* so large, at times, as to incapacitate the mites for any movement, and the great thing lies on its back kicking its legs in the air utterly unable to even hold itself right side up. The swimming powers are feeble and the animal sinks at once to the bottom where it clambers clumsily about, fortunate if any soft object allows it to obtain a foothold, at a great disadvantage if it be on a bottom too hard to allow its claws to penetrate. An apparent immunity from this effect of parasitism is seen in the case of *A. aculeatus* which, living as it does along the edge of the mantle and about the exhalent aperature, is more exposed to currents of water and retains the length of legs, small size of body and activity of movement almost un-

Digitized by Google

impaired—indeed, it is quite as good a swimmer as *A. crassipes*. Aside from increase in size and unwieldiness of form, there is a lack of the bright coloring which makes the whole group such interesting objects of study. The method of oviposition leads finally to peculiarities of structure in connection with the female sexual organs, consisting of the spines about the genital opening previously referred to. If kept for some time in a vessel of water cannibalism is never resorted to, no food is taken, and after weeks of starvation the mites finally die.

Haldeman (42) says they do not suffer from cold, as they are pretty active in water a few degrees above the freezing point; and he has found them moving about in a *Unio*, the outside layer of which was frozen. Nevertheless, they become torpid instantly, he says, if placed in freezing water, though the torpidity remains but a short time, if the temperature be gradually raised. As a rule, the migrations of the mussel from shallow to deep water and its habit of burying itself in mud during the winter, must make the temperature conditions within the shell very constant. Equally uniform is the supply of food, which is furnished to the animal with a minimum amount of exertion.

This stability of conditions under which the animal lives would lead us to expect little variation among the mites and little is found. Cases occur, involving the number, size, form, etc., of acetabula on the genital plates, and to a slight degree the relative dimensions and characters of other parts. But in no case are these sufficient to cause any confusion amongst different species, even when these are found living together in the same mussel. Specific characters are well defined and constant, and with care in the examination of specimens and a knowledge of the characteristic structural features of each species, identification should be perfectly sure.

The strange thing is that under conditions so stable, so many species should occur. In this respect as compared with the European fauna ours seems remarkably rich, since we have now 13 recorded species of *Atax* as compared with 8 from all parts of the continent of Europe, and our list is likely to be increased by collections in the more distant parts of the coun-

Digitized by Google

try, although those so far made cover seven states, from New York and Pennsylvania to Nebraska, and represent, all told, forty-one localities—2 in New York, 4 in Pennsylvania, 21 in Michigan, 1 in Wisconsin, 4 in Illinois, 2 in Iowa, and 7 in Nebraska. Material would be especially valuable from the South and from the Pacific Coast, and it is hoped this paper may be an incentive to investigators to take up the work of collecting Hydrachnidæ from those regions. Any material sent to the writer will be gratefully acknowledged, and if desired, labelled specimens returned; he will also gladly respond to any requests for information concerning the group.

Finally, the author would be doing an injustice both to those who have very generously assisted him and to his own sentiments of grateful appreciation, did he fail to acknowledge that assistance. To Dr. Richard Piersig of Leipzig, Germany, and to Prof. F. Koenike of Bremen, he is indebted for literature, and to Prof. Koenike also for specimens; each has been very generous and to the kindness of each he acknowledges his indebtedness. Material has been received from Mr. R. A. Johnson of Harvard University, Dr. R. H. Ward of Troy, N. Y., Mr. Jas. B. Shearer of Bay City, Mich., Mr. M. Ricker of Burlington, Ia., Prof. H. M. Kelly of Cornell College, Ia., Mr. O. D. Noble of Linwood, Neb., and Prof. H. B. Ward of the University of Nebraska, to each of whom the author extends his grateful acknowledgments. To Prof. Ward and to his former teacher, Prof. J. E. Reighard of the University of Michigan, he extends his thanks for many personal favors, and he also acknowledges his obligation to Mr. Bryant Walker of Detroit, Mich., for assistance in the identification of the mussels collected. Finally, it is just and proper that he acknowledge the assistance of his wife in the routine of the examination of mussels collected. He shall feel that he has partially repaid his obligations to those mentioned if that which he has accomplished by their assistance shall meet with their approval.

Digitized by Google

BIBLIOGRAPHY.

VON BAER, CARL ERNST.

27. Beiträge zur Kenntniss der neideren Thiere. Nova Acta phys-med. Acad. Caes. Leop.-Carolinae nat. cur., xiii, pt. 2, 523–762. Bonnae, 1827.
Describes *A. ypsilophorus* as *Hydrachna concharum*.

BARROIS AND MONIEZ.

87. Catalogue des Hydrachnides recueillies dans le nord de la France. Lille, 1887. 36 pp.
A. crassipes (Müll.), *Cochleophorus spinipes* (Müll.), *C. vernalis* (Müll.), *A. ypsilophorus* (Bonz), *A. Bonzi* (Clap.).

VAN BENEDEN, P.J.

48. Recherches sur l'histoire naturelle et le développement de l' Atax ypsilophora (Hydrachna concharum), etc. Bruxelles, 1848. (24 pp., 1 pl.).
The species studied was *A. intermedius* Koenike.

BERLESE, ANT.

82. Acari, Myriopoda et Scorpiones hucusque in Italia reperta. 79 Fascicles and supplement. Padova, 1882—'96.
A. crassipes and "*A. limosus* Koch" (according to Piersig (96b), *A. limosus* Koch = *Cochleophorus spinipes* (Müll.).

BESSELS, EMIL.

69. Bemerkungen über die in unseren Najaden schmarotzender Atax-Arten. Jahreshft. d. Ver. vaterl. Naturk. Württ. xxv, 1869, 146-152. Transl. by W. S. Dallas in Ann. and Mag. Nat. Hist. vii, 1871, 55-59.
Observations on development, etc.

BONZ, CHRISTOPH. GOTTLIEB.

1783. Nova acta phys.-med. Acad. Caes. Leop.-Carolinae nat. cur., etc. Observatio x. vii, 52–53, Pl. I, f. 1–4. Norimbergae, 1783.
Describes *Acarus ypsilophorus*.

BRUZELIUS, RAGNAR MAGNUS.

54. Beskrifning öfver Hydrachniden, som förekomma inom Skåne. Akad. Abhandl. Lund, 1854.
Restricted the genus to the limits since recognized; includes in observations *A. crassipes* and *Coch. spinipes*.

NOTE.—In this bibliography no mention has been made of articles which are simply records of occurrence. The different references are indicated by date, together with letter following when necessary. The designation given to each reference corresponds to that in the card catalogue of the author. which is believed to be complete, and in which the sequence adopted is carefully chosen to indicate the order of publication. This designation is here retained to preserve a uniformity of citation in this and other papers.

Digitized by Google

CLAPARÈDE, EDOUARD.

68. Studien an Acariden. Zeitschr. für wiss. Zool., xviii, pt. 4, 1868, 446–480.
Describes fully the development of *A. ypsilophorus*; describes *A. Bonzi*.

DADAY, EUG. V.

97. Die Fauna des Balatonsees. x. Wassermilben (Hydrachniden). Result wiss. Erforsch. Balatonsees ii, pt. 1, 195–205.
Describes *Atax Hungaricus*,=*Cochleophorus spinipes* (Müll.),juv.

98. Mikroskopische Süsswasserthiere aus Ceylon. Természetr. Füzetek.,xxi, 1898, 128 pp., 55 text figures.
Describes *Atax nodosus* and *A. singalensis*, of which *A. nodosus* belongs to *Cochleophorus*.

DANA, (JAS. D.) AND WHELPLEY (JAS.).

36. On two American Species of the genus Hydrachna. Silliman's Amer. Jour. Sci. xxx, 1886, 354–359. Plate.
Describes *Hydrachna formosa* (= *A. ypsilophorus*) and *H. pyriformis* (spec. undet.).

DÙGES, ALF.

84. Naturaleza Mèxico, vi, 344.
Atax Alzatei, n. sp. (is a *Curvipes*).

DUGES, ANTOINE.

34. Recherches sur l'ordre des Acariens. Deuexième Memoire. Remarques sur la famille des Hydracnés. Ann. Sci. Nat. 2me Série i, Zool., 1834, 144–174, Pl. x, xi.
Restricted genus *Atax* by separation of *Diplodontus* and *Arrenurus*, but as types of *Atax* gives *Hydrachna histrionica* Herm. (a *Limnesia*) and *H. lutescens* Herm. (a *Piona*).

FABRICIUS, JOH. CHR.

1792. Entomologia Systematica, etc. Hafniae, 1792–1794, 4 vols.
In vol. ii, pp. 398–406, gives all of Müller's species but *H. grossipes*, under the genus *Trombidium*.

05. Systema Antliatorum, etc. Brunsvigae, 1805.
Establishes genus *Atax* (= *Hydrachna*, Müller).

GARNER, R.

64. On a Parasitical Acarus of the Anodon. Rept. 33d Meet. Brit. Ass. Adv. Sci. Notices, 114.
A. ypsilophorus causes growth of pearly prominences on inside of shell.

GIROD, PAUL.

89. Recherches anatomiques sur les Hydrachnides parasites de l'Anodonte et de l'Unio, Atax ypsilophorus et Atax Bonzi. Bull. Soc. Zool. France, xiv, 1889, 107–110. Jour. Roy. Mic. Soc. Lond., 1889, 746–747 (abstract).

93. Recherches sur la respiration des Hydrachnides parasites. Assoc. franç. Avanc. Sc. 22 Sess. Besançon, pt. 1, 248.

Digitized by Google

HALDEMAN, S. S.

42. On some American species of Hydrachnidae. Zoological Contributions, No. 1. Philadelphia, 1842.
Describes 9 spp. of mussel parasites under the "Genus ? *Unionicola*"—*U. oviformis*, *U. lactea* (both = *A. ypsilophorus*), *U. personata*, *U. humerosa*, *U. symmetrica*, *U. proxima*, *U. lugbris*, *U. unicolor*, *U. reticulata* (spp. undet.).

HALLER, G.

81a. Die Hydrachniden der Schweiz. Mitth. der naturforsch. Ges. in Bern. ii, 1881, 18–88, Pls. i–iv. Separate, Bern, 1882.
Synonymy and notes on *A. crassipes*, *A. ypsilophorus*, *Coch. spinipes*.

HARRINGTON, FLETCHER AND TYRRELL.

84. Report of the Entomological Branch for the season of 1883. Ottawa Field Naturalists' Club, ii, 1884, 134–140.
Atax Bonzi (incorrect identification ?) and *A. ypsilophorus* in America.

HENKING, H.

82. Beiträge zur Anatomie, Entwicklungsgeschichte und Biologie von *Trombidium fuliginosum* Herm. Zeit. f. wiss. zool, xxxvii, 1882, 553–668, Pls. xxxiv–xxxvi.

IHERING, H. VON.

92. On the Geographical Distribution of Atax. Tr. N. Zealand Inst., xxv, 252–253.

KOCH, C. L.

85. Deutschlands Crustaceen, Myriapoden und Arachniden. Regensburg, 1835–41 (40 parts). Also in Panzer's "Deutschlands Insekten," beginning with part 132.

87. Uebersicht des Arachnidensystems. Nürnberg, 1837–43 (4 parts).
In the former, simply describes species, in the latter arranges them systematically. Restricts *Atax* by separating from it the genera *Nesaea*, *Piona*, *Hygrobates*, *Hydrochoreutes*, *Atractides*, *Acercus*, *Marica* and *Limnesia*. Describes under *Atax*, *A. crassipes* (Müll.); *A. truncatus*, *albidus*, *truncatellus*, *confluens*, *elegans* (all = *A. crassipes* (Müll.)—Piersig, 96b); *A. figuralis*, *diaphanus*, *lobatus* (all = *A. figuralis* Koch-Piersig, 96b); *A. spinipes* (Müll.), *frenıger*, *falcatus*, *limosus*, *fastuosus*, *pictus*, *hyalinus*, *bifasciatus*, *furcula* (all = *Coch. spinipes* (Müll.)—Piersig, 96b); *A. vernalis* (Müll.) (*Cochleophorus*); *A. grossipes* (Müll.) (ident. ?) *A. minimus* Koch (ident. ?).

KOENIKE, F.

81a. Revision von H. Lebert's Hydrachniden des Genfer Sees. Zeitschr. f. wiss. Zool., xxxv, pt. 4, 1881, 613–628.

81b. Vorläufige Notiz über die Bedeutung der "Steissdrüsen" bei Atax crassipes (Müll.). Zool. Anz. iv, 1881, 356–357.

Digitized by Google

82. Ueber das Hydrachniden Genus Atax. Abh. naturw. Ver. Bremen, vii, 1882, 265–268.

90. Ein neuer Bivalven-Parasit. Zool. Anz. xiii, 1890, 138–140.
A. aculeatus, n. sp. from Germany.

90a. Eine Wassermilbe als Schneckenschmarotzer. Zool. Anz. xiii, 1890, 364–365.
A. Ampullariae, n. sp. from S. Brazil.

90b. Südamericanische auf Muschelthiere Schmarotzende Atax-Species. Zool. Anz, xiii, 1890, 424–427.
A. procurvipes, n. sp., *A. perforatus*, n. sp., *A. rugosus*, n. sp., *A. Jheringi*, n. sp. from S. Brazil.

91. Noch ein Südamericanischer Muschel-Atax. Zool. Anz. xiv, 1891, 15–16.
A. fissipes, n. sp. from S. Brazil.

91c. Kurzer Bericht über Nordamerikanische Hydrachniden. Zool. Anz., xiv, 1891, pp. 256–258.

93. Die von Herrn Dr. F. Stuhlmann in Ostafrica gesammelten Hydrachniden des Hamburger naturhistorischen Museum. Jahrb. wiss. Anst. Hamburg, x, 1893, 1–55, 3 Pls. Also separate.
Describes *A. spinifer*, n. sp., *A. simulans*, n. sp., (both *Cochleophorus*).

93c. Weitere Anmerkungen zu Piersig's Beiträgen zur Hydrachnidenkunde. Zool. Anz., xvi, 1893, 460–464.
A. triangularis Piersig not valid—name preoccupied by Say, 1821.

95. Hydrachniden. Aus; Deutsch-Ost-Africa. Vol. iv, Die Thierwelt Ost-Africas, Wirbellose Thiere. Berlin, Geog. Verlagshdlg. Dietr. Reimer, 1895. 18 pp.
A. spinifer Koen., *A. simulans* Koen., *A. spinipes* (Müll.), *A. pauciporus*, n. sp., *A. lynceus*, n. sp., *A. figuralis* Koch (figs. only) (all *Cochleophorus* but the last two).

95a. Liste des Hydrachnides recueillies par la Dr. Théod. Barrois en Palestine, en Syrie et en Egypte. Rev. Biol. Nord. Fr., vii, 1895, 139–147. Separate, Lille, 1895.
A. crassipes from Palestine.

95b. Nordamerikanische Hydrachniden. Abh. des naturwiss. Ver. zu Bremen, xiii, 1895, 167–226. Pls. i–iii. Also separate.
A. ypsilophorus (Bonz), *C. vernalis* (Müll.), *A. ingens*, n. sp., *A. fossulatus* n. sp., figs. of *A. procurvipes* Koen.

95d. Ueber bekannte und neue Wassermilben. Zool. Anz., xviii, 1895, 373–386, 389–392. 17 figs.
A. tricuspis, n. sp., (Germany), *A. Schmackeri*, n. sp. (China), *A. verrucosus*, n. sp. (Germany) (*Cochleophorus*), *A. callosus*, n. sp. (Germany) (also a *Cochleophorus*).

Digitized by Google

96. Holtseinische Hydrachniden. Forschungsber. aus der Biol. Station zu Plön., iv, 1896, 207-248. Pl.
A. crassipes (Müll.), *A. limosus* (Koch) Berlese, *C. spinipes*, (Müll), *C. vernalis* (Müll.), *A. ypsilophorus* (Bonz), *A. intermedius* Koen.

KRAMER, P.

75. Beiträge zur Naturgeschichte der Hydrachniden. Arch. f. Naturgesch, xli, 1875, 263-332.
Describes *A. coeruleus* and *A. loricatus*, both of which = *Coch. spinipes*.

77. Grundzüge zur Systematik der Milben. Arch. f. Naturgesch., xliii, 1877, 215-247.
Systematic.

80. Ueber die postembryonale Entwicklung bei der Milbengattung *Glyciphagus*. Arch. f. Naturgesch., xlvi, 1880, 103-110.

KRENDOWSKY, M. E.

78. [Ueber die Erscheinung der Metamorphose bei Wassermieben]. (Russian). [Arbeiten der naturf. Ges. Charkow]. 66 pp. 2 pls. On metamorphosis, Refers to *A. coeruleus* Kram. (*Cochl. spinipes.*)

85. [Les Acariens d'eau douce (Hydrachnides) de la Russie meridionale]. (Russian). [Arb. Naturf. Ges. Charkow]. xviii, 1885. 209-358. 2 pls.
A. crassipes Müll., *A. coeruleus* Kram., (*Coch. spinipes*), *A. ypsilophorus*, v. Ben. (*A. intermedius* Koen.), *A. corcharum* v. Baer (*A. ypsilophorus* (Bonz), "*A. Bonzi* v. Ben."

LABOULBENE, ALEX.

51. Description de quelque Acariens et d'une Hydrachne. Ann. Soc. Ent. France, 2 me sèrie, ix, 1857.
His *Hydrachna* (*Atax*) *viridana*, according to Neuman (79) belongs to *Arrenurus*.

LAMPERT, KARL.

93. Parasiten der Teichmuschel (Anodonta mutabilis Cless). Jahresheft Ver. vaterl. Naturk. Württ. l, 1893, 79-80.
A. intermedius Koen.

LEBERT, H.

79. Matériaux pour servir à l'étude de la faune profonde du lac Léman, par Dr. F. A. Forel. vi Série. Hydrachnides du Léman. Bull. Soc. Vaud. Sc. Natur., xvi, 1879, 327-377, 2 pls.
Refers to *A. ypsilophorus*, *A. crassipes*, and under "new genus, *Neumania*", describes *N. nigra* and *N. alba* (both=*C. spinipes*).

LEIDY, JOS.

83. On the reproduction and parasites of Anodonta fluviatilis. Proc. Acad. Nat. Sci. Phila.. 1883, 44-46.
A. ypsilophorus and *A. Bonzi* (?).

MÜLLER, OTTO FRIEDR.

1776. Zoologiae Danicae prodromus, etc. Hafniae, 1776. (274 pag.)

Digitized by Google

1781. Hydrachnæ, quas in aquis Daniae palustribus, etc., Lipsiae, 1781. (88 pp., 11 pls.)
Describes 4 sp., *Hydrachna crassipes* (*Atax*), *H. grossipes* (ident.?) *H. spinipes* (*Cochleophorus*), *H. vernalis* (*Cochleophorus*). Established *Hydrachna* to include all Water-mites.

NEUMAN, C. J.

80. Om Sveriges Hydrachnider, aus Konigl. Svenska Vet.-Akad. Hndlgr., xvii, (123 pp. 14 pls.). Separate, 1880.

OSBORN (H.) AND UNDERWOOD (L.).

86. Preliminary List of the Species of Acarina of North America. Can. Ent., xviii, 1886, 4–12.
Refer to "*A. humerosa*" and "*A. ypsilophorus*," with the query after each, "where described?"

PFEIFFER, CARL.

24. Naturgeschichte deutscher Land-und Süsswasser-Mollusken. (3 parts). Cassel, 1821; Weimar, 1824, '28.
Vol ii, p. 27–28, describes *Atax ypsilophorus* as *Limnochares anodontae*.

PIERSIG, RICH.

93a. Beiträge zur Hydrachnidenkunde, Zool. Anz., xvi, 1893, 393–399.
Desc. *A. triangularis*, n. sp. (*Cochleophorus deltoides*).

94b. Sachsens Wassermilben, Zool. Anz., xvii, 1894, 213–216.
Lists *A. crassipes*, *A. figuralis*, *A. intermedius*, *A. Bonzi*, *A. ypsilophorus*; proposes genus *Cochleophorus* and lists *C. spinipes*, *C. deltoides*, *C. vernalis*.

96. Beiträge zur Kentniss der in Sachsen einheimischen Hydrachden-Formen. Leipsig, 1896. (71 pp.).
Chars. genera.—*A. ypsilophorus* (Bonz), *A. intermedius* Koen., *A. Bonzi* (Clap.), *A. figuralis* Koch, *A. crassipes* (Müll.), *A. aculeatus* Koen., *A. tricuspis* Koen., *C. spinipes* (Müll.), *C. deltoides* Piersig, *C. vernalis* Koch., *C. verrucosus* (Koen.), *C. callosus* (Koen.)

97. Deutchlands Hydrachniden. Bibliotheca Zoologica, xxii. (5 parts issued.)
Includes the species listed in previons reference.

97a. Bemerkungen zur Hydrachnidenkunde. Zool. Anz., xx, 59-61.
Proposes new genus *Encentridophorus* for *A. spinifer* Koen. from E. Africa, and *Najadicola* for *A. ingens* Koen. from Canada.

RATHKE, JENS.

1797. Skrivter af Naturhist. selsk., iv, pt. 1, 175. Pl. x. 1797.
Redescribes *A. ypsilophorus* as *Trombidium notatum*.

SAY, THOMAS.

21. An account of the Arachnides of the United States. Jour. Acad, Nat. Sci., Phila., ii, 1821, 59–83. LeConte's Ed. of Writings, 1859, ii, 9–21.
Describes *Hydrachna triangularis* (prob. = *A. ypsilophorus*].

Digitized by Google

STOLL, OTTO.

87. Hydrachnidae. Godman and Salvin's Biologia Centrali-Americana; Zool. Part lix, 1887, 9–15. Pls. vii–ix.
Desc. *A. alticola*, *A. dentipalpis* and *A. septem-maculatus*.

VAN VLEET, A. H.

96. Ueber die Athmungsweise der Hydrachniden. Zool. Anz., xix, 1896, 505–507.

WALCKENAER [CHAS. A. DE] AND GERVAIS [PAUL].

44. Histoire Naturelle des Insectes. Aptères. Tom. iii; Paris; 1884. Neglecting all the advances made since the time of Dugés (84), enumerates under *Atax* 16 species belonging to several genera, among them *A. crassipes* Müll., *A. grossipes* Müll., *A. spinipes* Müll. (*Cochleophorus*), *A. vernalis* Müll. (*Cochleophorus*), *A. furcula* Koch and *A. freniger* Koch (= *C. spinipes* (Müll.)

WOLCOTT, R. H.

98. New American Species of the Genus Atax (Fab.) Bruz. Zool. Bull., i, 1898, 279–285.

EXPLANATION OF PLATES.

PLATE XXVIII.

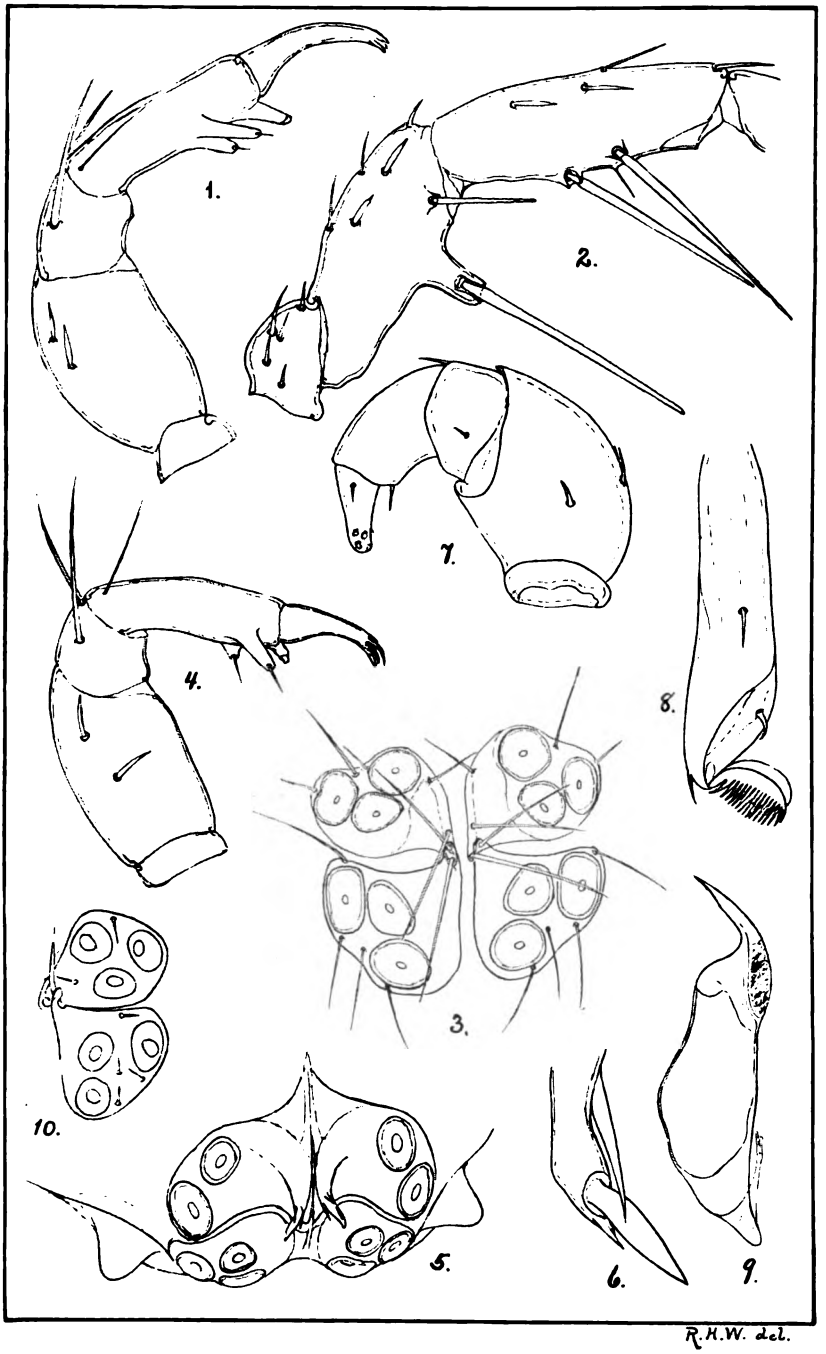
Fig. 1. *A. crassipes*. Outer side, right palpus. Male. x 180.
Fig. 2. *A. crassipes*. Three basal segments of leg I. x 180.
Fig. 3. *A. crassipes*. Genital area of female. x 250.
Fig. 4. *A. aculeatus*. Outer side, right palpus. Female. x 180.
Fig. 5. *A. aculeatus*. Posterior end of the body of a female, from the unmounted specimen. No attempt has been made to mark the location of hairs, but proportions and relative positions of parts shown are correct. x 180.
Fig. 6. *A. aculeatus*. Spine at the side of the genital opening of female. x 595.
Fig. 7. *A. pectinatus*. Outer side, left palpus of female. x 175.
Fig. 8. *A. pectinatus*. Distal segment, leg I. Male. x 340.
Fig. 9. *A. pectinatus*. Mandible. x 175.
Fig. 10. *A. pectinatus*. Half of genital area of female. x 175.

PLATE XXIX.

Fig. 11. *A. intermedius*. Outer side, left palpus of female. x 250.
Fig. 12. *A. intermedius*. Distal joint, hind leg of female. x 180.
Fig. 13. *A. abnormipes*. Outer side, left palpus of female. x 260.
Fig. 14. *A. abnormipes*. Anterior surface, right leg IV of male. x 175.
Fig. 15. *A. abnormipes*. Claw of right leg II of male. x 540.
Fig. 16. *A. indistinctus*. Outer side, right palpus of female. x 250.
Fig. 17. *A. indistinctus*. Ventral surface, leg IV of male—segments 4, 5 and 6. x 180.
Fig. 18. *A. serratus*. Mandible of female. x 185.

Digitized by Google

PLATE XXVII



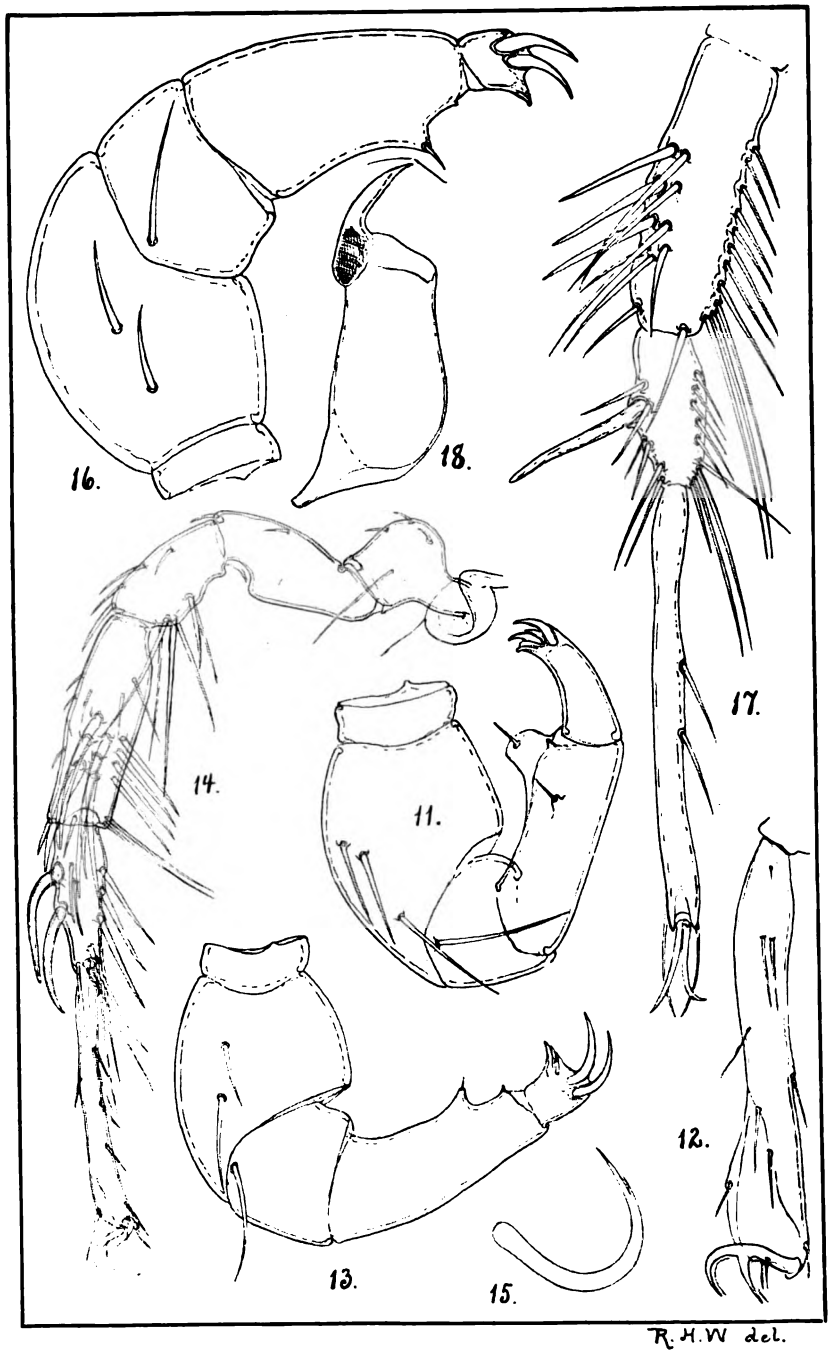
R.H.W. del.

Digitized by Google

Digitized by Google

Digitized by Google

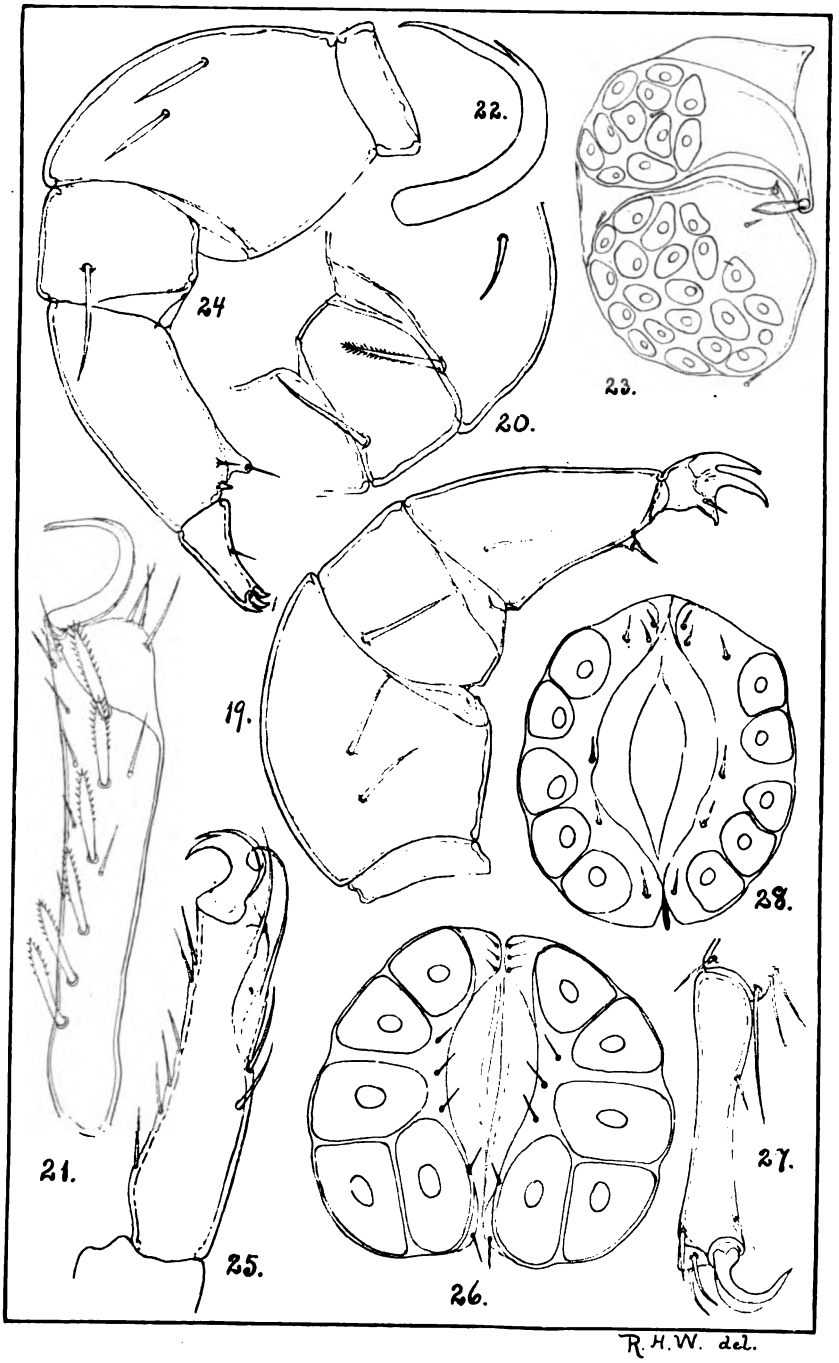
PLATE XXIX



R. H. W del.

Digitized by Google

PLATE XXX



R. H. W. del.

Digitized by Google

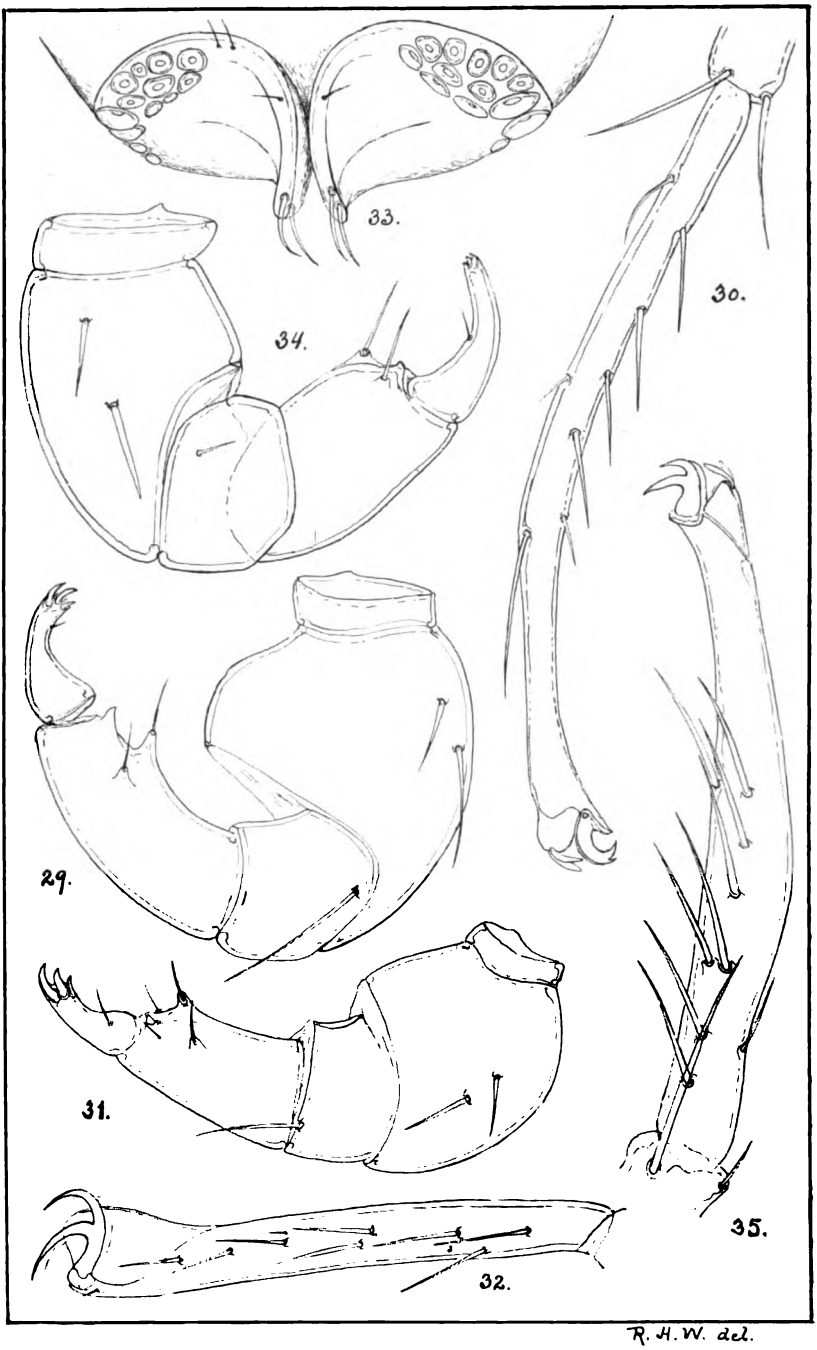
Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

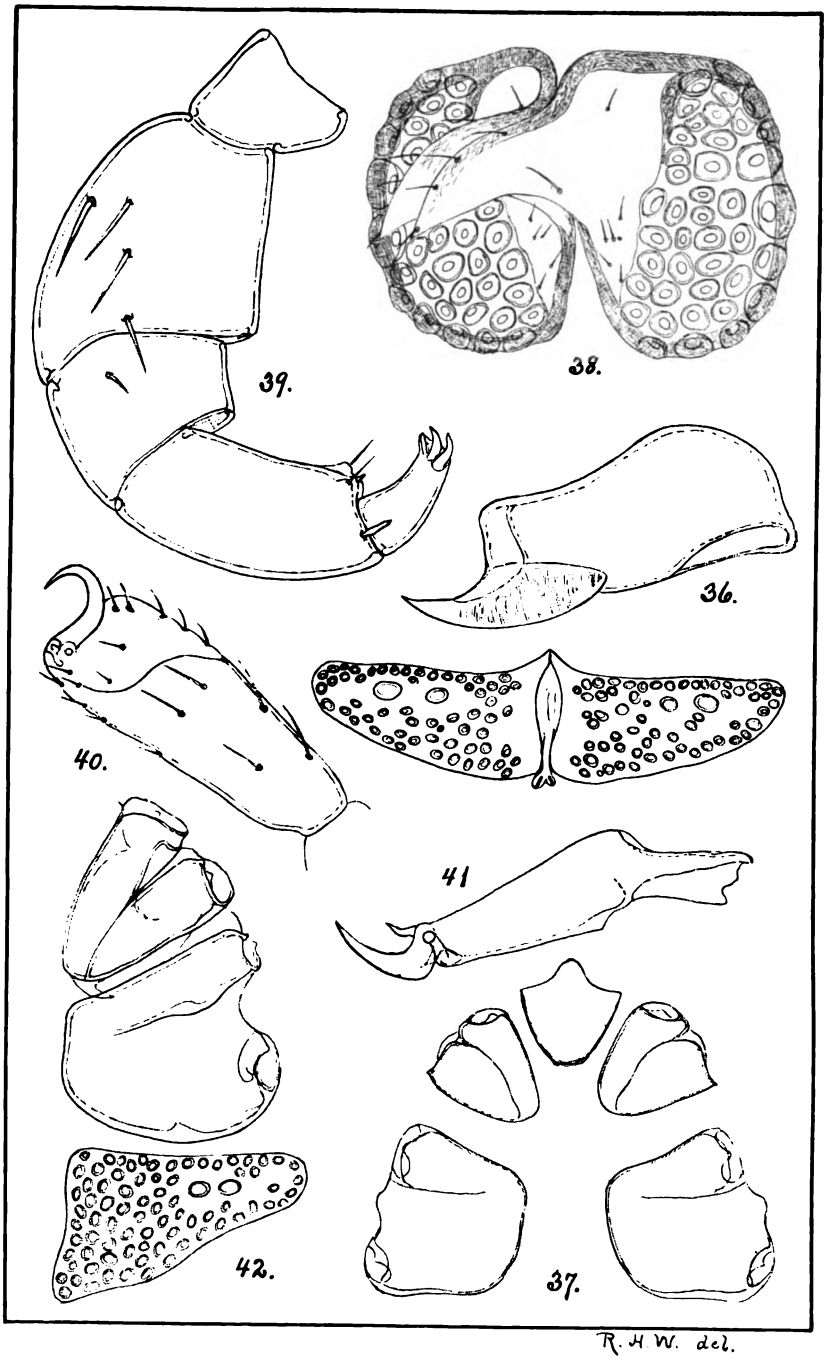
PLATE XXXI



R. H. W. del.

Digitized by Google

PLATE XXXII



R. H. W. del.

Digitized by Google

Digitized by Google

PLATE XXX.

Fig. 19. *A. serratus.* Outer side, right palpus of female. x 170.
Fig. 20. *A. serratus.* Inner side, part of left palpus. x 170.
Fig. 21. *A. serratus.* Distal segment, right leg IV of female. x 185.
Fig. 22. *A. serratus.* Claw of right leg II. x 540.
Fig. 23. *A. serratus.* One half of genital area of female. x 170.
Fig. 24. *A. fossulatus.* Outer side left palpus of male. x 180.
Fig. 25. *A. fossulatus.* Distal segment of first pair of legs. Female. x 250.
Fig. 26. *A. fossulatus.* Genital area of male. x 180.
Fig. 27. *A. stricta.* Distal segment of first pair of legs. Male. x 250.
Fig. 28. *A. stricta.* Genital area of male. x 250.

PLATE XXXI.

Fig. 29. *A. arcuata.* Outer side, right palpus of female. x 250.
Fig. 30. *A. arcuata.* Distal segment, last pair of legs, anterior surface. Female. x 190.
Fig. 31. *A. ypsilophorus.* Outer side, right palpus of female. x 180.
Fig. 32. *A. ypsilophorus.* Posterior surface, distal segment, right leg IV. Female. x 180.
Fg. 33. *A. ypsilophorus.* Posterior end of body of female from ventral aspect. x 180.
Fig. 34. *A. tumidus.* Outer side, left palpus of female. x 250.
Fig. 35. *A. tumidus.* Anterior surface of distal segment, leg IV. Female. x 190.

PLATE XXXII.

Fig. 36. *A. tumidus.* Mandible. x 180.
Fig. 37. *A. tumidus.* Outline of the epimera and maxillary shield of female. x 55.
Fig. 38. *A. tumidus.* Genital area of female. x 180.
Fig. 39. *A. (N.) ingens.* Inner side, palpus of male. x 180.
Elg. 40. *A. (N.) ingens.* Segment 6, first leg, anterior surface. Male. x 250.
Fig. 41. *A. (N.) ingens.* Mandible. x 180.
Fig. 42. *A. (N.) ingens.* Outline of epimera and genital plate of one side. Female. x 55. The line represents the median line of the body.
Fig. 43. *A. (N.) ingens.* Genital area of male, penis exserted. x 76.

Digitized by Google

Digitized by Google

FRESHWATER INVESTIGATIONS DURING THE LAST FIVE YEARS.

HENRY B. WARD.

It is just five years since the first report was published from the Plön Biological Station, the first general public enterprise of that character founded on fresh water and devoted to the solution of its problems. It is also just five years this summer since the Michigan Fish Commission inaugurated work on the Great Lakes by opening a laboratory on Lake St. Clair. The Plön station has given a great impetus to freshwater work in Germany, and to the efforts of the Michigan Fish Commission and its corps of scientists can be traced much of the energy now devoted to lacustrine investigation in this country. The half decade which has intervened since 1893 has seen great progress in this field and in view of the general interest taken in fresh water work at the present time it may not be adjudged untimely to give a résumé of the results achieved during this brief period. It seems fitting also to publish in this connection a bibliography which has been the result of much work on my part and which I hope may be of some service to other workers in this field, especially as no extended bibliography on this subject has yet been published and no summary of progress in this line is available in English at least.

While no effort has been spared to make the list of papers complete, it is too much to hope that no reference has been omitted which should have a place in its columns. On the main lines of investigation, however, I hope that no important article has been overlooked, but I should esteem it a favor to have errors or omissions called to my attention by those who note them. So far as possible all references have been verified from the original and have been abstracted for the summary of

Digitized by Google

progress, but in case of those articles not accessible, which in the list are designated by a star, it seemed better to make use of such reviews as were at hand in the various journals, or given in brief form on the cards of the Bibliographical Council at Zurich, in order that the cross references might be as complete as possible.

Of course such a bibliography could not reasonably be expected to give all references on some subjects which are in part included so that it is perhaps wise to state more specifically the limits of the work undertaken. With the exception of a single reference to Hensen, the father of plankton methods, a reference indispensable to all work, no mention has been made intentionally of any paper except as it deals in part at least with freshwater investigations. Nevertheless, some of the papers not seen may easily be devoted to marine studies even though no reference thereto is contained in the title. The bibliography is also essentially confined to zoological refercnces although some of the important papers on physical, chemical and botanical topics are cited. The papers of this character given are quoted from many sources, yet certainly do not comprehend all of importance on these topics. Their inclusion here is justified by their importance and bearing on the general problems of fresh water work, their immediate relation to the studies of certain investigators and localities, or their occurrence in such sources as render them easily accessible to the general student. Under the topics of taxonomy and geographical distribution, also, no effort has been made to collate all possible references; the endeavor has been rather to include all those papers of general or special interest and those of most immediate importance and accessibility to American students. Undoubtedly there is room here for cousiderable difference of opinion and the special student of a particular group or region will not find this bibliography extensive enough for his purposes, but I hope none the ess tha t it may be sufficiently representative to give a succinct and precise idea of the extent of our knowledge as to the distribution and composition of the freshwater life of the globe and the conditions under which it is found. In the systematic part greater

Digitized by Google

emphasis is laid upon those groups which are plankton forms, whereas others have received at most passing attention. There is also a considerable amount of literature bearing upon the technical phases of the subject, in its relation for instance to the purity of a city water supply, which has been included so far as references were found without any effort having been made to cover the entire ground.

It is in dealing with the field of plankton work that I have endeavored to include every article, however small, and to add references to such reviews as were noted in order to make the contents of the original articles more widely useful. In this I have been greatly aided by the admirable reviews of Zschokke in the Zoologisches Centralblatt; more recently Kofoid has undertaken similar abstracts in the American Naturalist. No effort has been made however to distinguish here between comments, reviews, and abstracts, or to include all such notices in the bibliography. A slight delay in the printing of the paper enables me to include references up to the close of 1898.

In so extended a review the method of citation must necessarily be brief yet such as to allow of the ready finding of papers cited. I have adopted the following:—The name of the author together with the year of publication of the article, bearing a letter affixed if necessary, forms the designation of the paper. The title of the article is not abbreviated, but written precisely as given by the author. The name of the journal is shortened as much as consistent with clearness and three or four which are in constant use, are designated as follows:

B. C. Biologisches Centralblatt.

J. R. M. S. Journal of the Royal Microscopical Society, London.

Z. A. Zoologischer Anzeiger.

Z. C. Zoologisches Centralblatt.

The abbreviations *vol.*, *pt.*, *p.*, etc., are entirely omitted but the following arbitrary order of arrangement will enable any reference to be read with ease.

Digitized by Google

The number of the volume is printed in lower case Roman numerals, and comes first, except that an antecedent Arabic figure may designate the series, if such exist. All other numbers are Arabic, and the last of these bearing no added designation is the page number. The latter may however be followed by the number of figures or plates in which case these numbers are always accompanied by a designative abbreviation, *fig.* or *pl.* The number, part, or article, is quoted only when paged separately, unless there was some uncertainty concerning some other part of the reference. Many references are incomplete, because (1) the article was entirely inaccesible, (2) the reprint in my library did not show the precise location of the article, or (3) disagreement between my card catalogue and the printed reference in one of the bibliographical records left uncertain the source of the error, and the paper referred to was not accessible here.

An example will perhaps make the method of citation clearer:

xiv, 4, means vol. xiv, page 4.

xiv, 4, 4, means vol. xiv, part or number 4, page 4.

4, xiv, 4, 4–42, means series 4, vol. xiv, part 4, page 4–42.

xxi, 1–3, 17–92. 4 pl. 7 fig., means vol. xxi, part 1 to 3, p. 17 to 92, 4 plates, and 7 text figs.

It is but fitting that I should acknowledge here my in debtedness to the various sources of information especially the bibliographical records in zoology; to the many individuals only a general acknowledgment of the courtesies can be made, but of my debt to Professor J. E. Reighard of the University of Michigan, who kindly placed his entire card catalog at my service, special mention should be made.

Digitized by Google

BIBLIOGRAPHY.

APSTEIN, C.

93. Ueber das Vorkommen von Cladocera gymnomera in holsteinischen Seen.
Schr. natw. Ver. Schles.-Holstein, x, 1. 4 pp.
Seasonal and numerical data on the species.

94. Vergleich der Planktonproduction in verschiedenen holsteinischen Seen.
Ber. Naturf. Ges. Freiburg i'Br., viii ("Festschrift für Weismann"), 70-88. 2 tab.
Rev. Z. C., i, 267-8; B. C., xiv, 319.

96. Das Süsswasserplankton. Methode und Resultate der quantitativen Untersuchung.
Kiel und Leipzig, 200 pp. 113 figs. 5 tab.
Rev. Z. C., iii, 764-9; Natw. Rundschau, xi, 87, 474; Science, n. s. vi, 140-1.

ATKINSON, E.

*98. Extraordinary Vitality of Entomostraca in Mud from Jerusalem.
Ann. Mag. Nat. Hist., 7, ii, 372-6.
Rev. Nat. Sci., xiv, 64.

BARROIS, TH.

*93. Notes préliminaire sur la faune des eaux douces de l' Orient.
Rev. Biol. Nord France, iii, 6, 230-4; 7, 277-81; 8, 316-8, 9 Fig.

*94. Contribution a l'étude de quelques lacs de Syrie.
Rev. Biol. Nord France, vii, 6, 224-313. 3 fig.
Rev. Z. C., i, 734-6 (=Zschokke, 94a, q. v.); B. C., xv, 869-73 (=Imhof, 95b, q. v.).

96. Recherches sur la faune des eaux douces des Açores.
Mém. Soc. Sc. Agric. Arts, Lille, 5, vi, 172 pp. 3 cartes.
Rev. Z. C., iii, 609-11; B. C., xvi, 683-8 (=Imhof, 96, q. v.).

BEDDARD, F. E.

93. The Fauna of the Victoria regia Tank in the Botanical Gardens.
Nature, xlix, 247.
Tropical animals introduced with aquatic plants.

BEHR, A.

*98. Die Fauna der wirbellosen Thiere des Babitsees.
Korr.-Bl. Nat. Ver. Riga, xl, 77.

BIGNEY, A. J.

97. Notes on the Biological Survey of Milan Pand.
Proc. Ind. Acad. Sci., 96, 274-5.
Brief preliminary report.

*References not seen by the reviewer are designated by a star.

Digitized by Google

BIRGE, E. A.

98. Notes on Cladocera, III.
Trans. Wis. Acad. Sci., ix, 275-317. 4 pl.
Taxonomic, notes on distribution.

94. A Report on a Collection of Cladocera mostly from Lake St. Clair, Michigan.
Bull. Mich. Fish Comm., 4, 45-7. 1 table.
Faunal list and discussion of species.

95. On the vertical distribution of the pelagic crustacea of Lake Mendota, Wis., during July, 1894.
B. C., xv, 353-5.
Résumé of the following article.

95a. Plankton Studies on Lake Mendota. I. The Vertical Distribution of the Pelagic Crustacea during July, 1894.
Trans. Wis. Acad. Sci., x, 421-84. 4 pl.
Rev. Z. C., ii, 847-8.

97. The Vertical Distribution of the Limnetic Crustacea of lake Mendota.
B. C., xvii, 871-4. Rev. Z. C., iv, 606-7.
Preliminary report on the work published in the next paper.

97a. Plankton Studies on Lake Mendota. II. The Crustacea of the Plankton, July, 1894–Dec., 1896.
Trans. Wis. Acad. Sci., xi, 274-448. 28 pl.
Rev. Z. C., v, 845-51; Am. Nat., xxxii, 282-4.

98. The Relation between the Areas of Inland Lakes and the Temperature of the Water.
Proc. Am. Fish. Soc., xxvii, 99-105. 1 chart.

BLANC, H.

*95. Les Résultats d'une série de pêches pélagique faites in 1894-5, dans le Léman.
Arch. sci. phys. et nat. Genève, 3, xxxiv, 460-2.
Rev. Z. C., iii, 814.

96. Sur le Plancton du lac Léman, sa distribution horizontale et verticale et sur les espèces les plus abondantes.
Actes Soc. helvet. sc. nat., lxxvii, 46-9.

*98. Plancton nocturne du lac Léman.
Bull. Soc. Vaud. sc. nat., 4, xxxiv, 128, 225-30; 129, 34-5.
Abst. J. R. M. S., 98, 618.

BLANCHARD, R., ET RICHARD J.

97. Sur la faune des lacs élevés des Hautes-Alpes.
Mém. Soc. Zool. France, x, 43–61. 1 fig. 1 tabl.
Rev. Z. C., iv, 512; B. C., xviii, 169–78 (= Imhof, 98, q. v.).

BLOCHMANN, F.

95. Die mikroscopische Thierwelt des Süsswassers I. Protozoa.
Hamburg, 2 aufl., 4°, 184 pp. 8 taf.
Rev. Z. C., iv, 285–6.
Chiefly taxonomic.

Digitized by Google

BÖHMIG, L.

98. Beiträge zur Anatomie und Histologie der Nemertinen.
Zeit. f. wiss. Zool., lxiv, 479–564. 5 pl.; also Arb. Zool. Inst. Graz, vi, 1; Rev. Z. C., v, 666–72.
Morphological. Valuable discussion of freshwater species.

BORELLI, A.

95. Viaggio del dott. A. Borelli nella Repubblica Argentina e nel Paraguay. XIII. Planarie d'acqua dolce.
Boll. Mus. Zool. Torino, x, 202, 1–6. Rev. Z. C., iv, 347.
Faunistic. Rarity of species noteworthy.

BRADY, G. S., AND NORMAN, A. M.

*96. A Monograph of the Marine and Freshwater Ostracoda of the North Atlantic and Northwestern Europe. Part II.
Sci. Trans. Roy. Soc. Dublin, v, 621–746. 19 pl.
Abst. J. R. M. S., 96, 810–1.

BREWER, A. D.

98. A study of the Copepoda found in the vicinity of Lincoln, Neb.
Jour. Cin. Soc. Nat. Hist., xix, 119–38, 1 pl.; also in Stud. Zool. Lab. Univ. Nebr. No. 29.

BROCKMEIER, H.

98. Süsswasserschnecken als Planktonfischer.
Forsch-ber. Biol. Stn. Plön, vi, 165.

BRUNER, L.

95. Animal Life in Thermal Springs. Insect Life, vii, 413–4. 1 fig.

BRUYANT, CH.

*94. Bibliographie raisonée de la faune et de la flore limnologiques de l'Auvergne.
Revue d'Auvergne, Clermont-Fd. 8°. 92 pp.

BUTSCHINSKY, P.

96. Die Protozoen-Fauna der Salzsee-Limane bei Odessa.
Z. A., xx, 194-7. Abstr. J. R. M. S., 97, 300.

CALKINS, G. N.

93. A Study of Odors observed in Drinking Waters of Mass.
Ann. Rept. Mass. Bd. Health, xxiv, 355–80. 1 pl.

93a. Seasonal Distribution of Microscopic Organisms in Surface Waters.
Ann. Rept. Mass. Bd. Health, xxiv, 383-92.

CALL, R. E.

97. The Hydrographic Basins of Indiana and Their Molluscan Fauna.
Proc. Ind. Acad. Sci., 96, 247-58. 1 pl.

CHILTON, C.

*94. The subterranean Crustacea of New Zealand; with some general remarks on the fauna of Caves and Wells.
Trans. Linn. Soc. London, Zool. 2, vi, 163–284. 8 pl.
Rev. Z. C., iii, 789–801, 821–7.

Digitized by Google

CHODAT, R.
97. Etudes de biologie lacustre.
Bull Herb. Boissier, 4, v, 289–314. Pl. Rev. Z. C., vi, 84.

CHUN, C.
*96. Zur Biologie der pelagischen Süsswasserfauna.
Jahresb. Schles. Ges. vat. Cult., Zool-bot. sect., xxxvii, 80–3.

COCKERELL, T. D. A.
96. Proposed Biological Station.
Psyche, vii, 242, Suppl. 1, 83.

DADAY, EUG. VON.
*94. Beiträge zur Kenntniss der Microfauna der Natronwässer des Alföldes. (Czeckish; latin diag.)
Naturhist. Hefte.
97. Beiträge zur Kenntniss der Microfauna der Tatraseen.
Term. Füzetek, xx, 149–96.
Rev. Z. C., iv, 607.
97a. Die Fauna des Balatons. IV. Nematoden.
Result. wiss. Erforsch. Balatonsees, ii, 1, 81–119.
Faunistic-systematic. Large number of species.
97b. Die Fauna des Balatons. V. Rotatoria.
Result. wiss. Erforsch. Balatonsees, ii, 1, 121–38.
97c. Die Fauna des Balatons. IX. Crustaceen.
Result. wiss. Erforsch. Balatonsees, ii, 1, 163–93. 40 fig.
Rev. Z. C., v, 374–5.
97d. Die Fauna des Balatons. X. Wassermilben (Hydrachniden).
Result. wiss Erforsch. Balatonsees, ii, 1, 195–205.
Faunistic-systematic. Scanty representation.
98. Mikroskopische Süsswasserthiere aus Ceylon.
Term. Füzet., xxi [Anhanghsheft], 123 pp., 55 text fig.
Rev. Z. C., v, 601–3; Am. Nat., xxxii, 880.

DAHL, FR.
94. Die Copepodenfauna des unteren Amazonas.
Ber. naturf. Ges. Freiburg i'Br., viii, 10–22. 1 pl.

DE GUERNE, J. G., see Guerne, J. G. de.

DOLAN, J. P.
97. Temperature of Lake Wawasee.
Proc. Ind. Acad. Sci., 96, 279-86.

DOLLEY, C. S.
96. The Planktonokrit, A Centrifugal Apparatus for the Volumetric Estimation of the Food-supply of Oysters and other Aquatic Animals.
Proc. Acad. Nat. Sci. Phila., 96, 276-89. 1 fig.

DRÖSCHER, W.
*97. Zur Begründung einer rationellen Fischwirthschaft.
Allg. Fisch. Zeit., xxii, 9-10.

Digitized by Google

*97a. Beitrag zur Kenntniss der Nahrung unserer Fische.
Allg. Fisch. Zeit., xxii, 19, 361-6; 20, 383-8.

*97b. Ein Beitrag zur Biologie der Seen.
Allg. Fisch. Zeit., xxii, 19, 369-71.

DROWN, THOS. M.

93. On the Amount of Dissolved Oxygen in the Waters of Ponds and Reservoirs at Different Depths, in Winter under the Ice.
Ann. Rept. Mass. Bd. Health, xxiv, 383-42.

DUPLESSIS, G., see Plessis, G. du.

DYBOWSKI, B.

*98. Switez. [Der Switez-See.]
Kosmos, Lemberg, xxii, 5, 252-75.

ECKSTEIN, K.

*95. Die Rotatorienfauna des Müggelsees. [Aus. d. Biol. Station d. deutsch. Fischerei-Vereines.]
Zeit. f. Fischerei, iii. 5 pp. 7 figs.
Rev. Z. C., ii, 756-7.
Scantily represented.

EIGENMANN, C. H.

95. Turkey Lake as a Unit of Environment and the Variation of its Inhabitants. (With faunal lists by numerous collaborators).
Proc. Ind. Acad. Sci., v, 204-96.

ENTZ, G.

96. Protozoa. Fauna regni hungariae.
Reg. Soc. Sci. Nat. Hung. Budapest. 29 pp.
Faunal list.

97. Einleitung und allegemeine Betrachtungen über die Fauna des Balatonsees.
Result. wiss. Erforsch. Balatonsees, ii, 1, 5-39. 5 fig.
Rev. Z. C., v, 351-2: Am. Nat., xxxii, 791-3.

EVERMANN, B. W.

93. The Investigation of Rivers and Lakes with Reference to the Fish Environment.
Bull. U. S. Fish Comm., xiii, 79-78.
Scope of work under the commission—outline for lake work.

FIELD, G. W.

96. Scientific Agriculture.
Rept. R. I. Bd. Agl., 96, 94-8.

97. On the Plankton of Brackish Water. [Abstract.]
Science, n. s., v, 424-5.

98. Use of the Centrifuge for collecting Plankton. [Abstract.]
Science, n. s., vii, 201.

98a. Methods in Planktology.
Rept. R. I. Exp. Sta., x, 2, 120-49; Am. Nat., xxxii, 785-45.

FITZGERALD, D.

95. The Temperature of Lakes.
Trans. Am. Soc. C. E., xxxiv, 67-114.

Digitized by Google

FORBES, E. B.

97. A Contribution to a Knowledge of North American Freshwater Cyclopidae.
Bull. Ill. Lab. Nat. Hist., v, 27-82. 18 pl.
Rev. Z. C., iv, 839-40.
Systematic monograph with important biological data.

FORBES, S. A.

93 A Preliminary Report on the Aquatic Invertebrate Fauna of the Yellowstone National Park, Wyoming, and of the Flathead Region of Montana.
Bull. U. S. Fish Comm., xi, 207-58, 6 Pl.
Rev. Z. C., i, 396-8; B. C., xiv, 287-93 (=Imhof, 94, q. v.)

94. Illinois State Laboratory of Natural History, Champaign, Ill. Biennial Report of the Director 1893-1894.
Chicago: Hornstein Brothers. 8°, 36 pp., 15 pls..
Cf. Nat. Sci., viii, 228-9; Science, n. s., ii, 729-30.

97. Biennial Report of the Biological Experiment Station, 1895-6.
Chicago. 35 pp. 20 pl. Cf. Nat. Sci., x, 365.

FORDYCE, CHAS.

98. A new Plankton Pump.
Proc. and Coll. Neb. St. Hist. Soc., 2, ii, 293-6; also Studies Zool. Lab. Univ. Nebr., No. 25. 2 fig.
Rev. Z. C., v, 603.

FOREL, F.-A.

92. Le Léman. Monographie Limnologique. Lausanne, i, 589 pp.

94. Zoologie lacustre.
Arch. sci. phys. et nat. Genève, 3, xxxii, 588-605.
Rev. J. R. M. S., 95, 161.

95. Le Léman. Monographie Limnologique. Lausanne, ii, 651 pp.

*96. Sur le Plancton du lac Léman.
Boll. Soc. Vaud. sc. nat., 4, xxxii, 121, 32-8.

FRANCE, R. H.

94. Zur Biologie des Planktons. Vorläufige Mittheilung.
B. C., xiv, 33-8. Cf. corrections by Hensen; B. C., xiv, 201.
Rev. Z. C., i, 308.

97. Die Fauna des Balatons. I. Protozoen.
Result. wiss. Erforsch. Balatonsees, ii, 1, 1-64.
Rev. Z. C., v, 322-3.

*97a. Der Organismus der Craspedomonaden.
Budapest, 1897. Rev. Z. C., v, 558-60; B. C., xviii, 535-6.
A monographic discussion of the group, including important biological notes.

FRENZEL, J.

*95. Die Biologische und Fischerei-Versuchsstation "Muggelsee". Bericht über die Jahre 1893 und 1894.
Zeit. f. Fisch., iii, 58-114. 4 fig. Also apart Berlin.

Digitized by Google

*95a. Die Bedeutung der biologischen Station für die fischwirthschaftliche Praxis.
Zeit. f. Fisch., iii, 175-8.

97. Zur Planktonmethodik. I. Die Planktonpumpe.
B. C., xvii, 190-8.
Abst. J. R. M. S., 97, 199.

97a. Zur Planktonmethodik. II. Die Seidengaze.
B. C., xvii, 364-71.

97b. Untersuchungen uber die mikroskopische Fauna Argentiniens I. Die Protozoen. 1, 2. Die Rhizopoden und Helioamoeben.
Bibl. Zool., 12, 166 pp. 10 Taf.
Rev. Z. C., v, 392-3.

FRIČ, ANTON.

97. Fresh-water Biological Stations. Europe's Example.
Nat. Sci., x, 169-72. 2 fig.

FRIČ, ANT. UND VÁVRA, V.

94. Untersuchungen über die Fauna der Gewässer Böhmens. IV. Die Thierwelt des Unterpocernitzer und Gatterschlager Teiches.
Arch. Natw. Landesdurchforsch. Böhmen, ix, 2, 124 pp. 80 fig.
Rev. Z. C., i, 736 (=Zschokke, 94a, q. v.); Nat. Sci., v, 370-5.

97. Untersuchungen über die Fauna der Gewässer Böhmens III. Untersuchung zweier Böhmerwaldseen, des Schwarzen und des Teufelsees.
Arch. Natw. Landesdurchforsch. Böhmen, x, 3, 74 pp. 32 fig.
Rev. Z. C., v, 158-9; Am. Nat., xxxii, 789-91.

FUHRMANN, O.

*94. Die Turbellarien der Umgebung von Basel.
Rev. Suisse Zool., ii, 216-90, 2 Taf.
Rev. Z. C., ii, 390-1.

95. Recherches sur la faune des lacs alpines du Tessin.
Rev. Suisse Zool., iv, 489-543.
Abst. Z. C., iv, 607-8; J. R. M. S., 97, 200.

GARBINI, A.

93. Primi materiali per una monografia limnologica del lago di Garda.
Mem. Accad. Agric. Art. Verona, 3, lxix, 73 pp.

*94. Primi materiali, etc., (93 with additions).
Bull. Soc. Ent. Ital., xxvi, i, 3-50.
Rev. Z. C., i, 552-3.

94a. Appunti per una limnobiotica italiana. I. Protozoa, Porifera e Coelenterata del Veronese.
Z. A., xvii, 295-8.
Rev. Z. C., i, 738 (=Zschokke, 94a, q. v.)
Faunal list with biological data.

95. Fauna limnetica e profonda del Benaco. (Osservazioni fatte nel 1894.)
Boll. Mus. Zool. Anat. Comp. Torino, x, 198, 7 pp.

Digitized by Google

95a. Appunti per una limnobiotica Italiana. II. Platodes, Vermes e Bryozoa del Veronese.
Z. A., xviii, 105-8.
Rev. Z. C., ii, 139.
Continuation of 94a.

95b. Diffusione passiva nella limnofauna.
Mem. Accad. Verona, 3, lxxi, 1, 10 pp.
Rev. Z. C., ii, 195-6.

95c. Appunti di carcinologia Veronese.
Mem. Accad. Verona, 3, lxxi, 1-94 pp., 1 tab.

95d. Appunti per una limnobiotica Italiana. III. Arthropoda del Veronese-Insecta e Arachnoidea.
Bull. Soc. Ent. Ital., xxvii, 12 pp.
Rev. Z. C., ii, 346.
Continuation of the list in 94a and 95a.

95e. Distribuzione e intensità della fauna atesina (Adige suoi influenti).
Mem. Accad. Verona, 3, lxxi, 2, 35 pp.

95f. Appunti per una limnobiotica Italiana. IV. Mollusca del Veronese.
Z. A., xviii, 411-4.
Rev. Z. C., ii, 680-1.
Continuation of the list in 94a, 95a and 95d.

*96. Osservazione biologiche intorno alle acque freatiche Veronesi.
Verona 87 pp.
Rev. Z. C., iii, 139.

96a. Intorno ai Nemertini del lago di Garda ed alla loro origine.
Z. A., xix, 125-7.

97. Alcune notizie fisiche sulle acque del Benaco.
Rivista Geogr. Ital., iv, 1, 29 pp.

98. Un pugillo di plancton del lago di Como.
Atti R. Inst. Veneto, 7, ix, 668-79.
Rev. Z. C., v, 487.
Cursory examination. Usual fauna.

98a. Due nuovi Rizopodi limnetici (*Difflugia cyclotelliana-Heterophrys Pavesii*).
Z. A., xxi, 667-70. 2 fig.
Systematic-faunistic.

GREVÉ, C.

*97. Zur Frage über die Nahrung der Süsswasserfische.
Allg. Fisch. Zeit., xxii, 288-90.

GUPPY, H. B.

*98. The Distribution of Aquatic Plants and Animals.
Scott. Geogr. Mag., ix, 28-33.

GUERNE, J. G. DE.

98. A propos d'une Méduse observèe par le Dr. Tautain dans le Niger, à Bamakou.
Bull. Soc. Zool. France, xviii, 225-30.
Rev. Z. C., ii, 19.

Digitized by Google

GIESBRECHT, W. UND SCHMEIL, O.

*98. Copepoda. 1. Gymnoplea.
Das Tierreich, 6, 169 pp. 31 fig.

GUERNE, J., ET RICHARD, J.

93. Sur la faune pélagique des lacs du Jura français.
C. R. Ac. Sci., Paris, cxvii, 187-9. Extr. Rev. Sci., lii, 158.
Rev. Z. C., i, 7-8.

93a. Sur la faune pélagique de quelques lacs des Hautes-Pyrénées
Assoc. franc. avanc. Sci., Congress de Pau, 1892.

96. Première liste des Copépodes et Cladocères d'eau douce du Portugal.
Bull. Soc. Zool. France, xxi, 157-9.
Rev. Z. C., iv, 486. J. R. M. S., 97, 86.
Faunal list—no new forms—mostly common European species.

GÜNTHER, R. T.

94. A Further Contribution to the Anatomy of *Limnocnida tanganyicae*.
Quar. Jour. Mic. Sci., xxxvi, 271-98. 2 pl.
Rev. Z. C., ii, 18-9.

HANITSCH, R.

*95. The Freshwater Sponges of Ireland with Remarks on the General Distribution of the Group.
Irish Natl., iv, 5, 122-31. 1 pl.
Rev. Z. C., ii, 587-8

HART, C. A.

95. On the Entomology of the Illinois River and Adjacent Waters.
Bull. Ill. Lab. Nat. Hist., iv, 149-273. 15 pl.
Rev. Nat. Sci., viii, 228-9.

HARTWIG, W.

97. Zur Verbreitung der niederen Crustaceen in der Provinz Brandenburg.
Forsch-ber. Biol. Stn. Plön, v, 115-49.

*98. Ueber das Vorkommen einiger "seltener" Entomostraken in der Provinz Brandenburg.
Natw. Wochenschr., xiii, 48-9.
Rev. Z. C., v, 375.

98a. Zur Verbreitung der niederen Crustaceen in der Provinz Brandenburg. Zweiter Beitrag.
Forsch-ber. Biol. Stn. Plön, vi, 140-52.
Rev. Z. C., v, 375-6.

*98b. Die Crustaceenfauna des Müggelsees während des Winters.
Zeit. f. Fisch., v, 113-9.
Rev. Z. C., v, 508.

HEMPEL, A.

96. Descriptions of New Species of Rotifera and Protozoa from the Illinois River and Adjacent Waters.
Bull. Ill. Lab. Nat. Hist., iv, 310-17. 5 pl. Rev. Z. C., iv, 55.

Digitized by Google

97. A List of the Protozoa and Rotifera found in the Illinois River and adjacent Lakes at Havana, Ill.
Bull. Ill. Lab. Nat. Hist., v, 301-88. 5 fig.

HENSEN, V.
95. Methodik der Untersuchungen.
Erg. d. Plankton Exp. d. Humboldt Stiftung., i, 200 pp. 11 pl.
97. Bemerkungen zur Planktonmechanik.
B. C., xvii, 510-2.

HERRICK, C. L.
95. Microcrustacea from New Mexico.
Z. A., xviii, 40-7. 29 figs. Abst. J. R. M. S., 95, 175.

HERRICK, C. L., AND TURNER, C. H.
95. Synopsis of the Entomostraca of Minnesota with descriptions of related species comprising all the known forms from the United States included in the orders Copepoda, Cladocera, Ostracoda.
Zool. Ser. ii, State Geol. Nat. Hist. Survey Minn. 525 pp. 81 pl.

HEUSCHER, J.
*93. Vorläufige Bericht über die Resultate einer Untersuchung des Walensees.
Schweiz. Fisch. Zeit., i.
*94. Bericht über eine Untersuchung von Teichen im Gebiet des Kantons St. Gallen.
Schweiz. Fisch. Zeit., ii.
*95. Ueber die Berner-Oberlandseen.
Schweiz. Fisch. Zeit., iii.

HICKSON, S. J.
*96. On the Distribution of the Freshwater Fauna.
Trans. and Ann. Rept. Manchester Mic. Soc., 96, 88-99.
Exc. Nat. Sci., xi, 79.

HOERNES, RUD.
97. Die Fauna des Baikalsees und ihre Reliktennatur.
B. C., xvii, 657-64. Rev. Z. C., iv, 825; J. R. M. S., 97, 524.

HOFER, B.
95. [Communication by Comte Eberhard de Zeppelin Ebersberg, q. v., on the Plankton of Lake Constance.]
Arch. sci. phys. et nat. Genève, 3, xxxiv, 458-60.
*96. Die Bedeutung von Planktonstudien für die Fischerei in Seen.
Allg. Fisch. Zeit., xxi, 355-9.

HOOD, J.
*95. On the Rotifera of the County Mayo.
Proc. R. Irish Acad., 3, iii, 664–706. Rev. Z. C., iv, 179–80.

HOPPE-SEYLER, F.
96. Ueber die Verteilung absorbirter Gase im Wasser des Bodensees und ihre Beziehungen zu den in ihm lebenden Tieren and Pflanzen.
Ver. f. Gesch. d. Bodensees u. seiner Umgebung, Heft 24, 20 pp.

Digitized by Google

HUITFELDT-KAAS, H.

98. Plankton in norwegischen Binnenseen.
B. C., xviii, 625-36; Rev. Z. C., v, 736-7.

IHERING, H. VON.

95. Os crustaceos phyllopodos do Brazil.
Revista Mus. Paulista, i, 165-80.

IMHOF, O. E.

*93. Les organismes inférieurs des lacs de la région du Rhône.
Arch. scl. phys. et. nat. Genève, 3, xxx, 646-52.
Rev. Z. C., i, 268.

94. Fauna hochgelegener Seen. Seen der Rocky-Mountains, Nord Amerika. Von S. A. Forbes.
B. C., xiv, 287-93.
Extended review of Forbes, 93.

94a. Die Rotatorien der grossen Seen in Michigan, Nord Amerika.
B. C., xiv, 494-5
Review of Jennings, 94.

95. Tierwelt der hochalpinen Seen.
B. C., xv, 506–17.
Review of Zschokke, 95.

95a. Summarische Beiträge zur Kenntnis der Aquatilia invertebrata der Schweiz.
B. C., xv, 718-19; Rev. Z. C., ii, 557; J. R. M. S., 95, 618.

95b. Th. Barrois, Fauna der Gewässer Syriens.
B. C., xv, 869-73.
Review of Barrois, Th., 94, q. v.

96. Die Binnengewässer-Fauna der Azoren. Referat nach de Guerne und Barrois.
B. C., xvi, 683-8.
Review of Barrois, Th., 96, and earlier work.

98. Fauna der Seen. I. Seen der europäischen Turkei und Montenegros. II. Seen der Alpen Savoyens.
B. C., xviii, 169-73.
Review of Richard, 97, and Blanchard et Richard, 97.

ISTVANFFY, J.

*94. Ueber die Nahrung der Fischbrut im Balaton-See.
S.-B. k. Ungar. natw. Ges., Budapest, 19 Apr.
Cf. Bot. Centr., lx, 172

JACKSON, D. D.

96. On an Improvement in the Sedgwick-Rafter Method for the Microscopical Examination of Drinking Water.
Tech. Quar., ix, 271-4. 1 pl. 1 table.

98. An Improved Filter for Microscopical Water Analysis.
Tech. Quar., xi, 241-5. 1 pl.

Digitized by Google

JACKSON, D. D., AND ELLMS, J. W.

97. On Odors and Tastes of Surface Waters, with Special Reference to Anabæna.
Tech. Quar., x, 410-20. 1 pl.

JANSEN, H.

*96. Der Müggelsee in geographischer, biologischer und fischereilicher Beziehung. (Verh. 6. deutsch. Fischereitages, Berlin, 1896.)
Zeit. f. Fisch., iv, 268-301. 2 Karten.

JAWOROWSKI, A.

*93. Neue Arten der Brunnenfauna von Krakau und Lemberg. (Czeckish; German résumé.)
Lemberg, 8°. 61 pp.

*96. Neue Arten der Brunnenfauna von Krakau und Lemberg.
Arch. f. Naturgesch., lxi, 1, 319-45. 1 taf.
Abst. J. R. M. S., 96, 301.

JELLIFFE, S. E.

93. The Chicago Water Supply in the World's Fair Grounds.
Am. Mo. Mic. Jour., xiv, 310-1.
Abst. J. R. M. S., 94, 328.

93a. A Preliminary List of the Plants found in the Ridgewood Water Supply of the City of Brooklyn, Kings County, N. Y.
Bull. Torrey Bot. Club, xx, 243-6.
Merely a faunal list.

*93b. A Preliminary Report on the Microscopical Organisms found in the Brooklyn Water Supply.
Brooklyn Med. Jour., Oct. 93.

*94. A Further Contribution to the Microscopical Examination of the Brooklyn Water Supply.
Brooklyn Med. Jour., Oct. 94.

JENNINGS, H. S.

94. A List of the Rotatoria of the Great Lakes and of Some of the Inland Lakes of Michigan.
Bull. Mich. Fish Comm., 3, 1-34. 1 pl.
Rev. B. C., xiv, 494-5 (= Imhof, 94a, q. v.); Abst. J. R. M. S., 94, 574.
Systematic-faunistic.

96. Report on the Rotatoria. With Description of a New Species.
Bull. Mich. Fish Comm., 6, 85-93. 2 figs.
Systematic-faunistic.

93. Trochosphaera Again.
Science n. s., viii, 551.
Found at Put-in-Bay, O. Not abundant.

JUDAY, C.

97. The Plankton of Turkey Lake.
Proc. Indiana Acad. Sci., 96, 287-96. 1 map.

Digitized by Google

KELLICOTT, D. S.

96. The Rotifera of Sandusky Bay.
Proc. Am. Mic. Soc., xviii, 155-64.

97. The Rotifera of Sandusky Bay, II.
Trans. Am. Mic. Soc., xix, 43-54. 3 figs.

KERTÉSZ, K.

*94. The Rotiferfauna of Budapest and Vicinity (Czeckish).
Budapest. 55 pp. Rev. Z. C., iii, 234-7.

KLÁPALEK. FR.

*93. Untersuchungen über die Fauna der Gewässer Böhmens.
I. Metamorphose der Trichopteren, II. Ser.
Arch. natw. Landesdurchf. Böhmens, viii, 6, 1-143. 38 figs.

KLEBAHN, H.

95. Allgemeiner Charakter der Pflanzenwelt der Plöner Seen.
Forsch-ber. Biol. Stn. Plön, iii, 1-17.

96. Ueber wasserblüthebildende Algen und über das Vorkommen von Gasvacuolen bei den Phycochromaceen.
Forsch-ber. Biol. Stn. Plön, iv, 189-206.

97. Bericht über einige Versuche betreffend die Gasvacuolen bei *Gloiotrichia echinulata*.
Forsch-ber. Biol. Stn. Plön, v, 166-79.

KLUNZINGER, C. B.

*96. Ueber die biologische Station zu Plön in Holstein.
Jahresh. Ver. vat. Naturk. Württ., lii, 80-1.

*96a. Ueber das Sammeln von Auftrieb.
Jahresh. Ver. vat. Naturk. Württ., lii, 124-5.

97. Die Lehre von der Schwebewesen des süssen Wassers oder Untersuchungeweisen und Ergebnisse der Limnoplanktonologie mit besonderer Rücksicht auf die Fischerei.
Zeit. f. Fisch., v, 120-70.

97a. Ferienstudien am Gardasee.
Jahresh. Ver. vat. Naturk. Württ., liii, 51-8.

KNAUTHE, K.

96. Zur Biologie der Süsswasserfische.
B. C., xvi, 410-6.

98. Der Kreislauf der Gase in unseren Gewässern.
B. C., xviii, 785-805.

KOCHS, W.

92. Versuche über die künstliche Vermehrung kleiner Crustaceen.
B. C., xii, 599-606; Zeit. f. Fisch., i, 157-63: Jahresh. rhein. Fisch. Ver. 90-1.

KOENIKE, F.

95. Nordamerikanische Hydrachniden.
Abh. naturw. Ver. Bremen, xiii, 167-226. 3 pl.
On a collection from Canada containing 80 species, 16 new.

Digitized by Google

KOFOID, C. A.

96. A Report upon the Protozoa observed in Lake Michigan and the Inland Lakes in the Neighborhood of Charlevoix, during the Summer of 1894.
Bull. Mich. Fish Comm., 6, 76-84.
Faunal list with notes.

96a. The Biological Experiment Station.
Illini, xxvi, 665-72. Figs.

96b. On the Occurence of *Trochosphaera solstitialis* in the Illinois River.
Science, n. s., iv, 935-6.
At Havana, Ill. Perhaps imported by human agency.

97. Plankton Studies. I. Methods and Apparatus in use in Plankton Investigations at the Biological Experiment Station of the University of Illinois.
Bull. Ill. Lab. Nat. Hist., v, 1-25. 7 pl.
Rev. Nat. Sci., x, 365-7; Z. C., iv, 518.

97a. On Some Important Sources of Error in the Plankton Method.
Science, n. s., vi, 829-32.
Rev. Z. C., v, 159-60.

98. Plankton Studies. II. On *Pleodorina illinoisensis*, a New Species from the Plankton of the Illinois River.
Bull. Ill. Lab. Nat. Hist., v, 273-93. 2 pl.

98a. Hints on the Construction of a Tow Net.
Jour. Appl. Mic., i, 111-3. 5 fig.

98b. The Freshwater Biological Stations of America.
Am. Nat., xxxii, 391-406.

KRÄMER, A.

97. Zur Mikrofauna Samoas.
Z. A., xx, 135-6.
Rev. Z. C., iv, 608. J. R. M. S., 97, 368.

LAKOWITZ, L.

96. Ein neues Horizontalschliessnetz.
Schr. Naturf. Ges. Danzig, ix, 275-9. 1 pl.
Rev. Z. C., v, 42.

LAMEERE, AUG.

*95. La faune des regions belgiques.
Feuille jeunes Nat., 3. xxvi, 58.

LAMPERT, K.

*93. Bemerkungen zur Süsswasserfauna Württembergs.
Jahresh. Ver. vat. Naturk. Württ., xlix, 102-9

*96. Das Thierleben unserer Seen im Winter.
Jahresh. Ver. vat. Naturk. Württ., lii, 103-4.

97-8. Das Leben der Binnengewässer.
Leipsig, 8°. 12 parts. 560 pp. Pl. and text figs.

Digitized by Google

LANGENBECK,

*93. Ueber die Bildung der Sprungschicht in den Seen.
Petermann's Mitth., xxxix.

LANKESTER, E. R.

93. Reappearance of the Freshwater Medusa (Limnocodium Sowerbii).
Nature, xlix, 127-8
Transfer from place to place with tropical plants.

LARGE, THOS.

97. Physical Survey of Lakes Tippecanoe, Eagle, Webster and Cedar.
Proc. Ind. Acad. Sci., 96, 296-302 4 maps.

LAUTERBORN, R.

*93. Ueber Periodicität im Auftreten und in der Fortpflanzung einiger pelagischen Organismen des Rheins und seiner Altwasser.
Ver. Nat. Hist.-Med. Vereins, Heidelberg, n. F., v, 1.

94. Ueber die Winterfauna einiger Gewässer der Oberrheinebene. Mit Beschreibungen neuer Protozoen.
B. C., xiv, 390-8.
Rev. Z. C., i, 465; J. R. M. S., 94, 440.

*94a. Beiträge zur Süsswasserfauna der Insel Helgoland.
Wiss. Meeresuntersuch., n. F., i, 217-21.
Rev. Z. C., ii, 102-3.

98. Ueber die zyklische Fortpflanzung limnetischer Rotatorien.
B. C,, xviii, 173-83.

*98a. Vorläufige Mittheilung über den Variationskreis von *Anuraea cochlearis* Gosse.
Z. A., xxi, 597-604. 6 fig. Abstr. J. R. M. S., 98, 89.

LEEDS, A. R.

97. Quantitative Estimation of Micro-Organisms.
Stevens' Indicator, xiv, 31-44. 1 pl.

LEMMERMANN, E.

95. Verzeichniss der in der Umgegend von Plön gesammelten Algen.
Forsch-ber. Biol. Stn. Plön, iii, 18-67.
Faunal list.

96. Zur Algenflora des Riesengebirges.
Forsch-ber. Biol. Stn. Plön, iv, 88-133.
Systematic-faunistic study.

96a. Zur Algenflora des Plöner Seengebietes. Zweiter Beitrag.
Forsch-ber. Biol. Stn. Plön, iv, 134-88.
Systematic-faunistic study.

97. Resultate einer biologischen Untersuchung der Forellenteiche von Sandfort.
Forsch-ber. Biol. Stn. Plön, v, 67-112. 2 fig. 1 plan.
Faunal list—discussion of value of different vegetation.

Digitized by Google

98. Der grosse Waterneverstorfer Binnensee. Eine biologische Studie.
Forsch-ber. Biol. Stn. Plon, vi, 167-204. 1 taf. Rev. Z. C.. v, 487.

LENDENFELD, R. VON.

96. Neuere Arbeiten über die Tiere der Finsterniss.
Z. C., iii, 789-801, 821-7.

LEVANDER, K. M.

94. Kleine Beiträge zur Kenntniss des Thierlebens unter dicker Eisdecke in einigen Gewässern Finnlands.
Meddel. Soc. Fauna Flora Fenn., xx, 6 pp.
Rev. Z. C., iii, 426

94a. Materialien zur Kenntniss der Wasserfauna in der Umgebung von Helsingfors, mit besonderer Berücksichtigung der Meeresfauna. I. Protozoa.
Acta Soc. Fauna Flora Fenn., xii, 2, 1-115. 3 taf.
Rev. Z. C., ii, 632-33; J. R. M. S., 94, 462.

94b. Materialien zur Kenntniss der Wasserfauna in die Umgebung von Helsingfors, mit besonderer Berücksichtigung der Meeresfauna. II. Rotatoria.
Acta Soc. Fauna Flora Fenn., xii, 3, 1-72. 3 taf.
Rev. Z. C.. ii, 754-6.

LINSBAUER

*95. Vorschlag einer verbesserten Methode zur Bestimming der Lichtverhältnisse im Wasser.
Verh. K. K. Zool-bot. Ges. Wien, 95.

LORENZ VON LIBURNAU, JOS.

*98. Der Hallstätter See. Eine limnologische Studie.
Mitth. geogr. Ges. Wien., xli, 1-218.

LORENZI, A.

*96. Una visita al laghetto di Cima Corso (Ampezzo).
Alto Croan. Soc. Alp. Friulana., vii, 10 pp. Rev. Z. C., iv, 52.

*97. La fauna dei laghi del Friuli.
Alto Croan. Soc. Alp. Friulana, vii. 6 pp.
Rev. Z. C., v, 487-8.

*98. Prime osservazioni zoologiche sulle acqua freatiche del Friuli.
Alto Croan. Soc. Alp. Friulana, ix. 9 pp.
Rev. Z. C., v, 737.
Subterranean waters. New species of *Niphargus*.

LUNDBERG, R.

*95. On the Postembryonal development of the Daphnids.
Bih. Kg. Svens. Vet. Ak. Handl., xx, 4, 2. 19 pp. 2 pl.
Rev. J. M. R. S., 96, 413.

MAGNIN, A.

*95. Les Lacs du Jura. 1, Généralités sur la limnologie jurassienne 2. Végétation des lacs du Jura suisse.
Paris et Lyon, 8°, 96 and 23 pp., 1 and 2 pl., 17 and 5 text-fig.

Digitized by Google

MARSH, C. D.

94. On the Vertical Distribution of Pelagic Crustacea in Green Lake, Wisconsin.
Am. Nat. xxviii, 807-9. Abst. J. R. M. S., 95, 311-2.

95. On the Cyclopidae and Calanidae of Lake St. Clair, Lake Michigan, and certain of the Inland Lakes of Michigan.
Bull. Mich. Fish Comm., 5, 1-24, 9 pl.
Abst. J. R. M. S., 96, 414.
Systematic-faunistic.

97. On the Limnetic Crustacea of Green Lake.
Trans. Wis. Acad. Sci., xi, 179-224, 10 pl.
Abst. J. R. M. S., 97, 534.

MCMILLAN, C.

93. The Gull Lake Biological Station of the University of Minnesota.
Science, xxi, 330.

MEZ, C.

*98. Mikroskopische Wasseranalyse. Anleitung zur Untersuchung des Wassers mit besonderer Berücksichtigung von Trink- und Abwasser.
Berlin, 8°. 631 pp., 8 Taf., 88 text-fig.
Rev. B. C., xviii, 507-9; Z. C., v, 446-7.

MIGULA, W.

*94. Methode und Aufgabe der biologischen Wasseruntersuchung.
Jahresb. Ver. Naturk. Manneim, 1, 20, 1-59.

MOENKHAUS, W. J.

98. Material for the Study of the Variation of *Etheostoma caprodes* Rafinesque and *Etheostoma nigrum* Rafinesque in Turkey Lake and Tippecanoe Lake.
Proc. Ind. Acad. Sci., 97, 207-228.
Adjacent lakes in different water-basins compared.

MONTGOMERY, T. H., JR.

95. Stichostemma Eilhardi n. g. et n. sp. Ein Beitrag zur Kenntnis der Nemertinen.
Zeit. f. wiss. Zool., lix, 88-146, 2 Taf. Rev. Z. C., ii, 146-9.
Detailed study of the structure of a freshwater nemertine.

95a. The Derivation of the Freshwater and Land Nemerteans, and allied Questions.
Jour. Morph., xi, 479-484.
Rev. Z. C., iii, 142-8.

96. Stichostemma asensoriatum n. sp., a Freshwater Nemertean from Pennsylvania.
Z. A., xix, 486-8. Abst. J. R. M. S., 97, 38.
Includes brief review of American freshwater species.

Digitized by Google

MOORE, J. E. S.
*97. On the General Zoological Results of the Tanganyika Expedition.
Proc. Zool. Soc., London, 97, 436-9.
97a. The Freshwater Fauna of Lake Tanganyika.
Nature, lvi, 198-200, 2 fig.
97b. The Fauna of the Great African Lakes.
Sci. Progress, vi, 627-41.
98. On the Zoological Evidence for the Connection of Lake Tanganyika with the Sea.
Proc. Roy. Soc. London, lxii, 451-8. 3 fig.
98a. The Mollusks of the Great African Lakes. 1. Distribution.
Quar. Jour. Mic. Sci., xli, 159-180.
98b. On the Hypothesis that Lake Tanganyika represents an Old Jurassic Sea.
Quar. Jour. Mic. Sci., xli, 303-21. 1 pl.
98c. The Marine Fauna in Lake Tanganyika and the Advisability of further Exploration in the Great African Lakes.
Nature, lviii, 404-8.

MOORE, J. P.
98. The Leeches of the U. S. National Museum.
Proc. U. S. Nat. Mus., xxi, 543-63. 1 pl.
Valuable taxonomic study on North American forms.

MRÁZEK, A.
*93. Beiträge zur Kenntniss der Süsswassercopepoden (Czeckish).
Vestnik spol., Prag, 93. 74 pp. 3 pl.
Rev. Z. C., i, 593-4; J. R. M. S., 95, 52.

MRÁZEK, A.
*93a. Beitrag zur Kenntnis der Harpakticidenfauna des Süsswassers.
Zool. Jahrb., Syst., vii, 89-130. 4pl. Rev. Z. C., i, 277.
*95. Copepoden. Deutsch-Ost-Afrika.
Wiss. Forsch-res., iv, 11 pp., 3 pl.

MÜLLER, O.
98. Bacillariales aus den Hochseen des Riesengebirges.
Forsch-ber. Biol. Stn. Plön, vi, 48-87. 3 pl.

NACHTRIEB, H. F.
94. Zoological Work during 1893 at the Gull Lake Biological Station.
Quar. Bull. Univ. Minn., ii, 5-7.

NOBRE, AUG.
*94. Estudos sobre a fauna aquatica dos rios do norte de Portugal.
Annaes sci. nat., Porto, i, 151-7.
Merely a faunal list.

NORDENSKIÖLD, E.
97. Notizen über Hydrachniden aus Süd-Finland.
Acta Soc. Faun. Flor. Fenn., xv, 1, 1-8.
Occurrence, distribution.

Digitized by Google

OLIVIER, E.
*94. Les Lacs d'Auvergne.
Rev. Sci. Bourbonn., vii, 117-9.

PACKARD, A. S.
94. On the Origin of the Subterranean Fauna of North America.
Am. Nat., xxviii, 727-51. 2 pl.
Rev. Z. C., ii, 137-9.

PERO, P.
*93. I laghi alpini valtellinesi. Parte I. Valle dell' Adda.
Nuova Notarisia, iv.

*93a. I laghi alpini valtellinesi. Parte II. Valle del Liro (Splugia).
Nuova Notarisia, iv, 117.

*93b. Richerche e studi sui laghi valtellinesi.
Nuova Notarisia, iv, 248-; 801-.

*94. I laghi alpini valtellinesi.
Nuova Notarisia, v, 413-; 670-.

*95. Cenni oroidrografici e studio biologico del lago di Mezzola.
Malpighia, ix, 71-112; 285-9.

95a. I laghi alpini valtellinesi. Fine.
Nuova Notarisia, vi, 1-13. 1 table. 1 map.

PETR, FR.
*94. Freshwater Sponges of Europe (Czeckish).
Gymnas. program, Chrudim, 32 pp. 2 pl. Rev. Z. C., ii, 301-2.

PIERSIG, R.
97. Deutschlands Hydrachniden.
Bibl. Zool. 22. (Not yet completed.)
Rev. Z. C., iv, 487-9.
Monograph of group with frequent important references to habitat in freshwater.

PIETERS, A. J.
94. The Plants of Lake St. Clair.
Bull. Mich. Fish Comm., 2, 1-10. 1 map.
Faunistic. Distinguishes aquatic plant formations.

PITARD, EUG.
*96. Sur le Plankton des lacs du Jura.
C. R. Soc. Helv. Sc. Nat., xxlxi, 152-5.

*96a. Le Plankton des lacs du Jura.
Arch. sc. phys. et nat. Genève, 4, ii. 4 pp.
Rev. Z. C., iv, 875-6.

97. La répartition quantitive en surface du Plankton.
Arch. sc. phys. et nat. Genève, 4, iii, 64-6. Rev. Z. C., iv, 513.

97a. Sur le Plankton du lac de Chavonnes.
Arch. sc. phys. et nat. Genève, 4, iii, 67-70. Rev. Z. C., iv, 513.

97b. Le Plankton du Lac de Lowerz.
Arch. sc. phys. et nat. Genève, 4, iii, 77-9. Rev. Z. C., iv, 513.

Digitized by Google

97c. Sur le plankton du lac de Joux.
Arch. sc. phys. et nat. Genève, 4, iii, 79-81. Rev. Z. C., iv, 514.

97d. Sur le plankton du lac de Brenet.
Arch. sc. phys. et nat. Genève 4, iii, 81-3. Rev. Z. C., iv, 514.

PLESSIS, G. DU.

*98. Organization et genre de vie de l' *Emea lacustris*, Nemertien des environs de Geneve.
Rev. Suisse zool., i, 329–57. 1 pl.

95. Note sur l'importation des Némertiens dans les eaux douces.
Z. A., xviii, 495-8. Rev. Z. C., iii, 143.

POPPE, S. A. UND MRÁZEK, W.

*95. Die von Herrn Dr. F. Stuhlmann auf Zanzibar und dem gegenüberliegenden Festlande gesammelten Süsswasser-Copepoden.
Jahrb. Hamburg. wiss. Anst., xii (Beiheft), 125-84. 2 pl.

*95a. Entomostraken aus Süd-Georgien.
Jahrb. Hamburg. wiss. Anst., xii (Beiheft), 135-8. 1pl.

*95b. Die von Herrn Dr. H. Driesch auf Ceylon gesammelten Süsswasser-Entomostraken.
Jahrb. Hamburg. wiss. Anst., xii (Beiheft), 139-42. 1 pl.

PUGNAT, C. A.

97. Première contribution à l'étude de la faune des lacs de la Savoie.
Revue Savois., 97, 9 pp. Rev. Z. C., iv, 469.

REIGHARD, J. E.

93. A Laboratory on the Great Lakes.
Z. A., xvi, 399-401.

94. Some Plankton Studies in the Great Lakes.
Bull. U. S. Fish Comm., xiii, 127-42. 2 pl.

94a. A Biological Examination of Lake St. Clair.
Bull. Mich. Fish Comm., 4, 1-41. 2 pl. 1 map.
Rev. Z. C., ii, 7-8; cf. Nat. Sci., x, 8-9.

94b. Suggestions for an Experimental Method of Determining the Efficiency of Quantitive Nets.
Bull. Mich. Fish Comm., 4, 57-60.

98. Methods of Plankton Investigation in their Relation to Practical Problems.
Bull. U. S. Fish Comm., xvii, 169-75.

RICHARD, J.

*93. Copépodes recueillis par. M. le Dr. Th. Barrois en Égypte, en Syrie, et en Palestine.
Rev. Biol. Nord France, v, 10. 36 pp. 51 fig.

93a. Sur la distribution géographique des Cladocères.
C. R. Congress Int. Zool., Moscou 1892. 9 pp.

94. Revision des Cladocères, 1.
Ann. Sci. Nat., zool., xviii, 279-389. 2 pl.

Digitized by Google

*94a. Cladocères recueillis par le Dr. Th. Barrois en Palestine, en Syrie et en Égypte.
Rev. Biol. Nord France, vi, 860-79. 12 fig.

94b. Sur quelques animaux inférieurs des eaux douces du Tonkin.
Mém. Soc. Zool. France, vii, 237-48.
Rev. Z. C., i., 810.

*94c. Entomostracés recueillis par M. E. Modigliani dans le lac Toba (Sumatra).
Ann. Mus. Civ. Genova, 2a, xiv, 565-78.

95. Cladocères et Copépodes recueillis par M. Kavraisky près de Tiflis et dans le lac Goktsha.
Bull. Soc. Zool. France, xx, 91-3.

95a. Sur quelques Entomostracés d'eau douce d'Haïti.
Mém. Soc. Zool. France, viii, 189-99. 11 fig.

*95b. Contribution à la faune des Entomostracés de la France.
Feuille Jeun. Naturl., 3, xxv, 9 pp. 6 fig. Rev. Z. C., iii, 322.
Faunal list.

96. Revision des Cladocères, II.
Ann. Sci. Nat., zool., 8, ii, 187-363. 6 pl.

96a. Sur la faune pélagique du Tegernsee.
Z. A., xix, 28-9.
Rev. Z. C., iii, 139-40.

96b. Sur la faune des eaux douces des Açores.
Bull. Soc. Zool. France, xxi, 171-8.
Abst. J. R. M. S., 97, 26; Z. C., iv, 469.
New forms reported; only cosmopolitan species.

96c. Sur la faune de quelques lacs élevés du Caucase d'après les récoltes de M. Kavraisky.
Bull. Soc. Zool. France, xxi, 183-5.
Abst. Z. C., iv, 469-70.

*97. Entomostracés recueillis par M. le Directeur Steindachner dans les lacs de Janina et de Scutari.
Ann. Nat. Hofmus. Wien, xii, 63-6. 1 fig.
Rev. Z. C., iv, 843.
Pelagic fauna poor, of 5 species, one new.

*97a. Sur quelques Entomostracés d'eau douce des environs de Buenos Aires.
Anal. Mus. nac. Buenos Aires, v, 321-32. 6 fig.
Rev. Z. C., iv, 843.

97b. Entomostracés de l'Amérique du Sud, recueillis par MM. U. Deiters, H. v. Jhering, G. W. Müller, et C. O. Poppe.
Mém. Soc. Zool. France, x, 263-301. Rev. Z. C., iv, 842-3.

98. Sur la faune des eaux douces des îles Canaries.
C. R. Ac. Sci. Paris, cxxvi, 439-41.
Rev. Z. C., v, 353.

Digitized by Google

98a. Sur la faune des eaux douces explorées en 1898 pendant la campagne du yacht "Princesse Alice."
Mém. Soc. Zool. France, xi, 826-38.

RICHTER, P.

94. *Gloiotrichia echinulata* P. Richt., eine Wasserblüte des Grossen und Kleinen Plöner Sees.
Forsch-ber. Biol. Stn. Plön, ii, 31-46.

RIZZARDI, U.

*94. Risultati biologici di una esplorazione del lago di Nemi.
Boll. Soc. Rom. stud. zool., 3, iii, 137-57.
Rev. Z. C., ii, 195.

*96. Gli Entomostraci del lago di Mezzola.
Boll. Soc. Rom. stud. zool., 3, v, 126-9.
Abstr. J. R. M. S., 97, 124.
Appendix to Pero, 95, q. v. Limnetic species few.

ROSS, L. S.

96. Preliminary Notes on the Iowa Entomostraca.
Proc. Iowa Acad. Sci., 95, iii, 170-3.
Faunal list.

97. Some Manitoba Cladocera with Description of one New Species.
Proc. Iowa Acad. Sci., iv, 154-62.
Systematic-faunistic.

97a. A New Species of Daphnia and Brief Notes on Other Cladocera of Iowa.
Proc. Iowa Acad. Sci., iv, 162-6. 2 fig.

97b. The Illinois Biological Station.
Proc. Iowa Acad. Sci., iv, 167-70.

RUSSELL, I. C.

95. Lakes of North America.
Ginn & Co., Boston. 125 pp. 8 fig. 23 pl.

SARS, G. O.

*94. Contributions to the Knowledge of the Freshwater Entomostraca of New Zealand.
Vid.-Selks. Forh. Christiania, 94, 5. 62 pp. 7 pl.

*95. On Some South African Entomotraca raised from dried mud.
Vid.-Selks. Forh. Christiania, 95, 8, 1-56. 8 pl.

*96. On Freshwater Entomostraca from the Neighborhood of Sidney.
Arch. Math. Natw., xviii, 2, 1-81. 8 pl.

SCHACHT, F. W.

97. The North American Species of Diaptomus.
Bull. Ill. Lab. Nat. Hist., v, 97-207. 15 pl.
Rev. Z. C., v, 227.
Taxonomic; data on distribution, seasonal variations; bibliography.

Digitized by Google

98. The North American Centropagidae belonging to the Genera Osphranticum, Limnocalanus and Epischura.
Bull. Ill. Lab. Nat. Hist., v, 225-69.
Rev. Z. C., v, 713-4; Am. Nat., xxxiii, 164-5.
Systematic-faunistic with valuable bibliography.

SCHARFF, R. F.

*95. On the Origin of the Land and Freshwater Fauna of Ireland.
Proc. R. Irish Acad., 3, iii, 479-85.
Rev. J. R. M. S., 95, 161; Nat. Sci., vi, 147-8.

SCHAUDINN, F.

96. Heliozoa. Das Tierreich, 1-24.
Abstr. J. R. M. S., 96, 427.
Systematic.

SCHEWIAKOFF, W.

*93. Ueber einige ekto- und entoparasitiche Protozoen der Cyclopiden.
Bull. Soc. Imp. Nat. Moscou, 93, 1, 1-29. 1 taf.
Rev. Z. C., i, 8-9.
Description of tycholimnetic species.

93a. Ueber die geographische Verbreitung der Süsswasser-Protozoen.
Mém. Ac. Imp. Sc. St. Pétersbourg, 7, xli, 8, 201 pp. 4 taf.
Rev. Z. C., i, 813-5; J. R. M. S., 95, 821-2.

SCHMEIL, O.

92. Deutschlands freilebende Süsswasser-Copepoden. I. Cyclopidae.
Bibl. Zool., 11, 192 pp. 8 pl.

93. Deutschlands freilebende Süsswasser-Copepoden. II. Harpacticidae.
Bibl. Zool., 15, 103 pp. 8 pl.
Rev. Z. C., i, 278.

*93a. Copepoden des Rhätikon Gebirges.
Abh. naturf. Ges. Halle, xix.

*94. Zur Höhlenfauna des Karstes.
Zeitsch. f. Naturwiss., lxvi, 339-53.
Rev. Z. C., i, 464-5; also iii, 790-801.

96. Deutschlands freilebende Süsswasser-Copepoden. III. Centropagidae.
Bibl. Zool., 21. 144 pp. 12 pl.
Rev. Z. C., iv, 65-8; J. R. M. S., 96, 522-3.

98. Deutschlands freilebende Süsswasser-Copepoden. Nachtrag.
Bibl. Zool., 21, 145-88. 2 Taf.
Rev. Z. C., iv, 841-2.

Digitized by Google

SCHRÖDER, B.

97. Die Algenflora der Versuchsteiche.
Forsch-ber. Biol. Stn. Plön, v, 29-66. 8 pl.
Systematic-faunistic.

97a. Ueber das Plankton der Oder.
Ber. Deutsch. Bot. Ges., xx, 482-92. 1 pl.

98. Neue Beiträge zur Kenntnis der Algen des Riesengebirges.
Forsch-ber. Biol. Stn. Plön, vi, 9-47.

98a. Planktologische Mittheilungen.
B. C., xviii, 525-35.

SCHRÖDER, B. UND ZACHARIAS, O.

*97. Ueber die Flora und Fauna der Versuchsteiche des Schlesischen Fischerei-Vereins zu Trachenberg in Schlesien.
1. Die Vegetationsverhältnisse der Versuchsteiche, B. Schröder, p. 28-36.
2. Die Fauna des Versuchsteiche, O. Zacharias, p. 36-51.
Zeit. f. Fischerei, v, 28-40; 41-51. 11 fig.

SCHRÖTER, C.

*97. Schwebeflora unserer Seen. Das Phytoplankton.
Neujahrsblatt naturf. Ges. Zürich, xcix, 60 pp. 3 pl. 3 fig.
Rev. B. C., xvii, 209-12; Arch. sci. phys. et nat. Genève, 3, iii, 577-8.

SCHRÖTER, C., UND KIRCHNER, O.

*96. Die Vegetation des Bodensees.
Bodensee-Forschungen, ix. Absch. Lindau i' B.
Rev. B. C., xvii, 593-9.

SCOTT, A. AND T.

*95. On New and Rare Species of Copepoda from Scotland.
Annals Scot. Nat. Hist., No. 13, 28-35. 1 pl.

*95a. Notes on Some Rare Freshwater and Marine Copepoda from Scotland.
Annals Scot. Nat. Hist., No. 16, 233-9. 1 pl.

SCOTT, T.

93. The Invertebrate Fauna of the Inland Waters of Scotland. Part III.
Ann. Rept. Fish Bd. Scotland, xi, 220-38. 2 pl.

*94. The Invertebrate Fauna of the Inland Waters of Scotland. Part IV.
Ann. Rept. Fish Bd. Scotland, xii, 284-90.

95. The Invertebrate Fauna of the Inland Waters of Scotland. Part V.
Ann. Rept. Fish Bd. Scotland, xiii, 237-57. 2 pl.

*95a. Notes on Freshwater Entomostraca with Special Reference to Loch Leven.
Annals Scot. Nat. Hist., No. 15, 163-173.

Digitized by Google

96. The Invertebrate Fauna of the Inland Waters of Scotland. Part VI.
Ann. Rept. Fish Bd. Scotland, xiv, 167-70.
Rev. Z. C., iv, 376.
Faunal lists of several lakes and comparison of the same.

97. The Invertebrate Fauna of the Inland Waters of Scotland. Part VII.
Ann. Rept. Fish Bd. Scotland, xv, 316-27. 1 pl.
Rev. Z. C., v, 160.
Comparison of nine Scotch lakes with faunal lists and descriptions.

98. The Invertebrate Fauna of the Inland Waters of Scotland. Part VIII.
Ann. Rept. Fish Bd. Scotland, xvi, 248-52. 4 pl.

SCOTT, T., AND DUTHIE, R.

95. The Inland Waters of the Shetland Islands.
Ann. Rept. Fish Bd. Scotland, xiii, 174-91. 1 pl.

96. The Inland Waters of the Shetland Islands. Part II.
Ann. Rept. Fish Bd. Scotland, xiv, 229-48. 1 pl.
Rev. Z. C., iv, 376.
An examination of numerous bodies of water; fauna scanty, interesting.

97. An Account of the Examination of some of the Lochs of Shetland.
Ann. Rept. Fish Bd. Scotland, xv, 327-33.
Rev. Z. C., v, 160.
Further studies show an increase on previous list of species.

98. Account of the Examination of some of the Lochs of Shetland.
Ann. Rept. Fish Bd. Scotland, xvi, 253-60.

SCOURFIELD, D. J.

93. The Entomostraca of Wanstead Park.
Jour. Quekett Mic. Club, 2, v, 161-78.
Abst. J. R. M. S., 94, 567.

*94. Entomostraca and the Surface-film of Water.
Jour. Linn. Soc. London, xxv, 158, 1-19. 2 pl.
Abst. J. R. M. S., 95, 52.

95. A Preliminary Account of the Entomostraca of North Wales.
Jour. Quekett Mic. Club, 2, vi, 127-43. 1 pl.
Rev. Z. C., iii, 462.
No macrofauna; poor littoral, rich limnetic microfauna.

*96. On the Necessity for a British Freshwater Station.
Rep. Brit. A. A. S. Liverpool, lxvi, 831-2.

97. Wanted, a British Freshwater Biological Station.
Nat. Sci., x, 17-9; cf. viii, 8-9.

97a. The Logarithmic Plotting of Certain Biological Data.
Jour. Quekett Mic. Club, 2, vi, 419-23. 1 pl.

Digitized by Google

97b. Contributions to the Non-Marine Fauna of Spitzbergen.
Proc. Zool. Soc. Lond., 97, 784-92. 1 pl.

97c. Verzeichniss der Entomostraken von Plön.
Forsch-ber. Biol. Stn. Plön, v, 180. 1 tab.
Faunal list.

98. The Entomostraca of Epping Forest. Part I.
Essex Nat., x, 193-210.

98a. The Entomostraca of Epping Forest. Part II.
Essex Nat., x, 259-74. 3 tables.

98b. The Entomostraca of Epping Forest. Part III and IV.
Essex Nat., x, 313-34.
Rev. Am. Nat., xxxiii, 161-2.

SEKERA, E.
*98. Studie limnobiologicke.
Program Gymnas., Pilgram, Bohemia. 28 pp.

SELIGO, A.
*98. Ueber einige Flagellaten des Süsswasserplankton.
Festgabe Westpr. Fisch. Ver. z. d. 150 jähr. Jubil.
Naturf. Ges. Danzig.

97. Zur Wasserpestfrage.
Allg. Fisch.-Zeit., xxii, 19-20. 7 pp.

SERNOW, N.
97. Daily Variations in the Plankton Volumes in Deep Lake (Russian).
Arb. Ichth. Sect. k. Acclim. Ges., ii, 210.
Table of amounts; cf. Zograf, 97.

SEURAT, L. G.
*98 Sur la faune des lacs et lagunes du valle de Mexico.
Bull. Mus. Hist. Nat. Paris, 98, 23-7.

SHARPE, R. W.
97. Contribution to a Knowledge of the North American Freshwater Ostracoda included in the Families Cytheridae and Cyprididae. (With an extensive bibliography).
Bull. Ill. Lab. Nat. Hist., iv, 414-84. Pl. 39-48.
Rev Z. C., iv, 527-8.

SIMROTH, H.
*96. Ueber Landpflanzen und Landthiere im heimischen Süsswasser.
Mitth. a. d. Osterlande, n. F., vii, 105-25.
Rev Z. C., iv, 509-12.

SMITH, F.
94. List of the Protozoa and Mollusca observed in Lake St. Clair in the Summer of 1893.
Bull. Mich. Fish Comm., 4, 42-4.
Faunistic.

Digitized by Google

SMITH, H. M.
98. Biological Survey of Lake Erie.
Science, n. s., viii, 13-4.

SMITH, J. C.
97. Notices of Some Undescribed Infusoria, from the Infusorial Fauna of Louisiana.
Trans. Amer. Mic. Soc., xix, 55-68. 1 pl.

SOAR, C. D.
97. Presidential Address: a few words on Water-mites.
Journ. Micros. and Nat. Sci., vii, 12 pp.
Contains notes on occurrence, means of collecting, etc.

STECK, TH.
93. Beiträge zur Biologie des grossen Moosseedorfsee's.
Mitt. Naturf. Ges. Bern, 93, 20-73, 1 pl.

STENROOS, K. E.
95. Die Cladoceren der Umgebung von Helsingfors.
Acta Soc. Faun. Flor. Fenn., xi, 2, 1-44. 1 pl.
Rev. Z. C., iii, 324.

97. Zur Kenntniss der Crustaceenfauna von Russisch-Karelien.
Acta Soc. Faun. Flor. Fenn., xv, 2, 1-72, 1 pl. 1 chart, 1 table.

98. Das Thierleben im Nurmijärvi-See.
Acta Soc. Faun. Flor. Fenn., xvii, 1, 1-259, 3 pl. 1 ch.
Rev. Z. C., v, 603-6; Am. Nat., xxxii, 793-4.

STEUR, A.
*97. Copepoden und Cladoceren des süssen Wassers aus der Umgebung von Triest.
Verh. kk. zool.-bot. Ges. Wien, 97, 16 pp. 1 taf.

*97a. Ein Beitrag zur Kenntniss der Cladoceren und Copepodenfauna Kärntens.
Verh. kk. zool-bot. Ges. Wien, 97, 49 pp. 6 fig.

STINGELIN, TH.
95. Ueber die Cladocerenfauna der Umgebung von Basel.
Z. A., xviii, 49-51. (Preliminary).
Abst. J. R. M. S., 95, 426.

*95a. Die Cladoceren der Umgebung von Basel.
Rev. Suisse Zool., iii, 161-274. 4 pl.
Rev. Z. C., iii, 322-4; J. R. M. S., 96, 62.

97. Ueber jahreszeitliche, individuelle und locale Variation bei Crustaceen, nebst einige Bemerkungen über die Fortpflanzung bei Daphniden und Lynceiden.
Forsch-ber. Biol. Stn. Plön, v, 150-65, 5 text fig.
Rev. Z. C., iv, 625-6.

STOCKMAYER, O.
94. Das Leben des Baches (des Wassers überhaupt).
Ber. Deutsch. Bot. Ges., xii, (Appendix) 133-41.

Digitized by Google

STOKES, A. C.
96. Aquatic Microscopy for Beginners.
Portland, Conn., 3d Ed., 326 pp. 198 text-fig.

STRODTMANN, S.
95. Die Ursache des Schwebvermögens bei den Cyanophyceen (vorläufige Mitth.).
B. C., xv, 113-5.

*95a. Die Anpassung der Cyanophyceen an das pelagische Leben.
Arch. Entw-mech. Organismen, i, 3.

95b. Bemerkungen über die Lebensverhältnisse des Süsswasser plankton.
Forsch.-ber. Biol. Stn. Plön, iii, 145-79.

96. Planktonuntersuchungen in holsteinischen und mecklenburgischen Seen.
Forsch-ber. Biol. Stn. Plön, iv, 273-87.
Rev. Z. C., iii, 447-8.

97. Ueber die Nahrung einiger Wildfische.
Zeit. f. Fischerei, v, 103-12.

98. Ueber die vermeintliche Schädlichkeit der Wasserblüte.
Forsch-ber. Biol. Stn. Plön, vi, 206-12.

STUDER, TH.
*93. Faune du lac de Champex.
Arch. sc. phys. et nat. Genève, 3, xxx, 151-8. Rev. Z. C., i, 214.
Pelagic fauna little developed. List of forms observed.

SUNDVIK, E. E.
*96. Bidrag till fragan om fiskarnas resp. de kallblodiga djurens öfvervintring. (German resumé).
Meddel. Soc. Fauna Flora Fenn., 21, 12-4.
Rev. Z. C., iv, 51-2.

ŠVEC, F.
97. Beiträge zur Kenntniss der Infusorien Böhmens. I. Die ciliaten Infusorien des Unterpocernitzer Teiches.
Bull. Internat. Acad. Sci. Bohême, 97, 19 pp. 2 pl.

SZIGETHY, K.
97. Die Fauna des Balatons. III. Turbellarien.
Result. wiss. Erforsch. Balatonsees, ii, 1, 73-9.
Faunistic-systematic.

THOMAS, FR.
*97. Ein neuer durch *Euglena sanguinea* erzeugter, kleiner Blutsee in der baumlosen Region der Bündner Alpen.
Mitth. Thüring. Bot. Ver., n. F. x, 28-34.
Rev. Z. C., iv, 778.
Small pool, 2160 m. alt., blood red with *Euglena*.

Digitized by Google

THOMPSON, H. D.

96. A Biological Examination of Lake Michigan. The Aquatic Plants.
Bull. Mich. Fish Comm., 6, 72-5.
Faunal list with notes.

TURNER, C. H.

93. Additional Notes on the Cladocera and Ostracoda of Cincinnati, Ohio.
Bull. Sci. Lab. Denison Univ., viii, 1-18, 2 pl.

94. Notes on American Ostracoda with Description of New Species.
Bull. Sci. Lab. Denison Univ., viii, 2, 13-26. 2 pl.

ULE, W.

*93. Die Temperaturverhältnisse der baltischen Seen.
Verh. x. deutsch. Geographentages, Stuttgart.

*91. Beiträge zur Instrumentenkunde auf dem Gebiete der Seenforschung.
Petermann's Mitth., xl.

94a. Geologie und Orohydrographie der Umgebung von Plön.
Forsch-ber. Biol. Stn. Plön, ii, 1-19.

VÁNGEL, E.

97. Die Fauna des Balatons. II. Coelenterata. Schwämme und Hydren.
Result. wiss. Erforsch. Balatonsees, ii, 1, 65-71.
Faunistic-systematic.

97a. Die Fauna des Balatons. VI. Moosthiere (Bryozoa).
Result. wiss. Erforsch. Balatonsees, ii, 1, 135-43.
Faunistic-systematic.

97b. Die Fauna des Balatons. VII. Gliederwürmer (Annelides).
Result. wiss. Erforsch. Balatonsees, ii, 1, 145-51.
Faunistic-systematic.

VÁVRA, W.

*93. Ein Beitrag zur Kenntniss der Süsswasserfauna von Bulgarien.
S.-B. K. Böhm. Ges. Wiss., Math.-natw. Kl., xlvi, 4 pp.
Rev. Z. C., i, 398.
Numerous species of cosmopolitan character.

97. Die Süsswasser-Ostracoden Deutsch-Ost-Afrikas.
Ostafrika, iv, 28 pp. 59 fig.
Rev. Z. C., iv, 486-7.
Faunal study. Most forms known, yet not reported from Africa.

98. Süsswasser-Ostracoden der Hamburger Magalhaenischen Sammelreise.
Hamburg. 1-26 pp. 5 fig.

VEJDOVSKY, FR.

95. Zur vergleichende Anatomie der Turbellarien. (Zugleich ein Beitrag zur Turbellarien-Fauna Böhmens.)
Zeit. f. wiss. Zool., lx, 90-162, 4 pl; 163-214. 3 pl.

Digitized by Google

VESCOVIE, P. DE.

*96. Notizie sulla formazione di un nuova lago nella provincia di Roma e Considerazioni da punta di vista della fauna lacustre. Boll. Soc. Rom. Stud. zool., v, 55-71.

VIRE, A.

*95. Sur quelques animaux habitants les cavernes du Jura. Bull. Mus. Hist. Nat. Paris, 95, 243-5.

*96. Animaux cavernicoles. Bull. Mus. Hist. Nat. Paris, 96, 90-2; also note p. 139.

96a. Modifications apportées aux organes de relation et de la nutrition chez quelques Arthropodes par le séjour dans les cavernes. C. R. Acad. Sci., cxxii, 486-7. Trans. Ann. Mag. Nat. Hist., xvii, 407-8. Rev. Z. C., iii, 321-2, 790.

*97. La faune obscuricole des conduits d'eau de Seine de la ville de Paris et le projet de dérivation des sources du Lunai. Bull. Mus. Hist. Nat. Paris, 97, 237-42.

VOIGT, W.

*95. Ueber Thiere die sich vermuthlich aus der Eiszeit her in unseren Bächen erhalten haben. Verh nath. Ver. preuss. Rheinl., lii, 235-44. Rev. Z. C., iv, 340-1.

*96. *Planaria gonocephala* als Eindringling in das Verbreiterungsgebeit von *Planaria alpina* and *Polycelis cornuta*. Zool. Jarb., Syst., viii, 131-76. 3 karten,

96a. Die Einwanderung der Planariaden in unsere Gebirgsbäche. Verh. nath. Ver. preuss Rheinl., liii, 103-18. 1 pl.

VOLZ, W.

98. Ueber neue Turbellarien aus der Schweiz (vorl. Mitth.). Z. A., xxi, 605-12. Figs.

WAGNER, PAUL.

*97. Die Seen des Böhmerwaldes. Eine geologisch-geograpische Studie; zugleich ein Beitrag zur Lösung des Karproblems. Leipzig.

*97a. Fishfang im Gardasee. Die Natur, xlvi, 616-7.

WALKER, B.

95. A Month with the Michigan Fish Commission. Nautilus, xi, 2-6. Description of the molluscan fauna.

95a. Review of our Present Knowledge of the Molluscan Fauna of Michigan. Detroit. 27 pp.

96. Report upon the Mollusca Collected in the Vicinity of Charlevoix, Michigan, in the Summer of 1894. Bull. Mich. Fish Comm., 6, 96-9. Faunal list with notes.

Digitized by Google

WALTER, E.

98. Biologie und Biologische Süsswasserstationen.
Forsch-Ber. Biol. Stn. Plön, ii, 138-47.

95. Eine praktisch-verwerthbare Methode zur quantitativen Bestimmung des Teichplanktons.
Forsch-ber. Biol. Stn. Plön, iii, 180-7.
Rev. Z. C., ii, 72.

95a. Ueber die Möglichkeit einer biologischen Bonitirung von Teichen.
Allg. Fisch. Zeit., xx, 14 pp.; also Jahresb. Schles. Fisch-Ver.

*96. Zielen und Wege der Teichwirthschaft.
Zeit. f. Fischerei, iv, 144.

*96a. Ein Versuch die teichwirtschaftliche Station in Trachenberg unmittelbar für die Praxis nutzbar zu machen.
Zeit. f. Fischerei, iv.

*96b. Die natürliche Nahrung unserer Teichfische.
Allg. Fisch. Zeit, xxi, 374-7.

WARD, H. B.

94. A Preliminary Report on the Worms (mostly Parasitic) Collected in Lake St. Clair, in the Summer of 1893.
Bull. Mich. Fish. Comm., 4, 49-54, 1 table; also in Stud. Zool. Lab. Univ. Nebr., No. 4.
Faunistic.

95. The Food Supply of the Fish in the Great Lakes.
Nebr. Lit. Mag., i, 107-24, 2 pl.; also in Stud. Zool. Lab. Univ. Nebr., No. 11; Bien. Rept. Mich. Fish Comm., xii, 117-29.

96. The Food Supply of the Great Lakes, and Some Experiments on its Amount and Distribution.
Trans. Amer. Mic. Soc., xvii, 242-54, 2 pl.; also in Stud. Zool. Lab. Univ. Nebr., No. 12.
Rev. Z. C., iii, 208-5.

96a. A New Method for the Quantitative Determination of Plankton Hauls.
Trans. Amer. Mic. Soc., xvii, 255-60; also in Stud. Zool. Lab. Univ. Nebr., No. 13.
Rev. Z. C., iii, 225; Ber. Fisch. Ver. Ost-Preussen.

96b. A Biological Examination of Lake Michigan in the Traverse Bay Region.
Bull. Mich. Fish. Comm., 6, 1-71, 5 pl.; also in Stud. Zool. Lab. Univ. Nebr., No. 16.
Rev. Z. C., iv, 176-7; J. R. M. S., 97, 25; cf. Nat. Sci., x, 8-9.

98. Report of the Zoologist. Fish Food in Nebraska Streams.
Ann. Rept. Nebr. Bd. Agr., 97, 272-9; also in Stud. Zool. Lab. Univ. Nebr., No. 28.
Rev. Z. C., v, 606.
Brief discussion of conditions and list of species found.

Digitized by Google

98a. Aquacultural Experiment Stations and their Work.
Proc. Amer. Fish. Soc., xxvii, 125-9.

WARD, R. H.

95. Improved Methods of Collecting Aquatic Micro-Organisms.
Amer. Mo. Mic. Jour., xvi, 33-41. 1 pl.

WARREN, H. E., AND WHIPPLE, G. C.

95. The Thermophone, a New Instrument for Obtainining the Temperature of a Distant or Inaccessible Place and Some Observations on the Temperature of Surface Waters.
Amer. Meteorol. Jour., xii, 35-50. 2 pl.

*95a. The Thermophone, A New Instrument for Determining Temperatures.
Tech. Quar., viii.

WEBER, E.-F.

98. Faune rotatorienne du bassin du Léman (1re partie).
Rev. Suisse Zool., v, 263-354. 6 pl.
Abst. Am. Nat. xxxiii, 163.

98a. Faune rotatorienne du bassin du Léman (2me partie).
Rev. Suisse Zool., v, 355-785. 10 pl.

WEBER, M.

*97. Beiträge zur Kenntniss der Fauna von Süd-Afrika, I. Zur Kenntniss der Süsswasserfauna von Südafrika.
Zool. Jahrb., Abt. Syst., x, 135-200. 1 pl. 2 charts.
Rev. Z. C., iv, 825-8; J. R. M. S., 97, 275.

WELTNER, W.

*94. Forschungsberichte aus der Biologischen Station zu Plön.
Zeit. f. Fischerei, ii, 5.

*95. Spongillidenstudien, III. Katalog und Verebreitung der bekannten Süsswasserschwämme.
Arch. f. Naturges., 95, i, 114-44.
Rev. Z. C., ii, 521-2.
Taxonomic; data on distribution, regions, etc.

95a. Biologische Süsswasserstationen.
In M. von dem Borne, Künstl. Fischzucht, Berlin, 186-96. 16 fig.

*96. Die Cladoceren Ost-Afrikas.
Deutsch Ostafrika, iv.

*96a. Die Coelenteraten und Schwämme des Süssen Wassers Ostafrikas.
Deutsch Ostafrika, iv, 1-8. Rev. Z. C., iv, 401.

WESENBERG-LUND, C.

*94. Grönlands Ferkswandentomostraca, I. Phyllopoda branchiopoda et Cladocera.
Vid. Med. Nat. Forh. Kjobenhavn. p. 82.

*96. Biologisk Undersogelser over Ferskvandorganismer.
Vid. Meded. Nat. Forh. Kjobenhavn, (5), vii, 105-74.

98. Ueber dänische Rotiferen und über die Fortpflanzungsverhältnisse der Rotiferen.
Z. A., xxi, 200-11. Rev. J. R. M. S., 98, 309.

Digitized by Google

WESTERN, G.

94. Some foreign Rotifers to be included in the British Catalogue.
Jour. Quekett Mic. Club, 2, v, 420-6.
Rev. Z. C., iv, 181-2.
Faunal list with important biological data.

WHIPPLE, G. C.

94. Some Observations on the Growth of Diatoms in Surface Waters.
Tech. Quar., vii, 214.
Rev. J. R. M. S., 95, 345; Amer. Mo. Mic. Jour., xvi, 140-5.

94a. Synura.
Amer. Mo. Mic. Jour., xv, 257-62. 1 pl.
Cf. Ann. Rept. Boston Water Board, xviii.

94b. A Standard unit of size for Micro-Organisms.
Amer. Mo. Mic. Jour., xv, 377-81, 2 fig. 1 pl.
Abst. J. R. M. S., 95, 386.

95. The Thermophone.
Science, n. s., ii, 639-43.

95a. Some Observations on the Temperature of Surface Waters; and the Effect of Temperature on the Growth of Micro-Organisms.
Jour. New Eng. W. W. Assn., ix, 202-22. 5 pl.

96. Experience with the Sedgwick-Rafter Method at the Biological Laboratory of the Boston Water Works.
Tech. Quar., ix, 275-9.

96a. Some Observations on the Relation of Light to the Growth of Diatoms.
Jour. New Eng. W. W. Assn., xi, 1-26. 5 pl.

*96b. Report on the Organisms in the Boston Water Supply.
Ann. Rept. Boston Water Works, xix.

97. Microscopical Examination of Water, with a Description of a Simple Form of Apparatus.
Science, n. s., vi, 85-9.

97a. Raphidomonas.
Jour. New Eng. W. W. Assn., xi, 348-56. 1 pl.
Extraordinarily abundant in Lynn water supply on one occasion.

97b. Biological Studies in Massachusetts, No. 1.
Am. Nat., xxxi, 503-8. 2 pl.

97c. Biological Studies in Massachusetts, No. 2. Microscopical organisms.
Am. Nat., xxxi, 576-81.

97d. Biological Studies in Massachusetts, No. 3. Geographical distribution of microscopical organisms.
Am. Nat., xxxi, 101-626.

Digitized by Google

98. Classification of Lakes according to Temperature.
Am. Nat,, xxxii, 25-33.

*98a. Some Observations on the Growth of Organisms in Water Pipes.
Jour. New Eng. W. W. Assn., xii, 1.

WIERZEJSKI, A.

98. Die Räderthiere Galiziens. (Czeckish; German abstract).
Anz. Akad. Wiss. Krakau, xxvi, 161-265. 8 pl.

*95. Przeglad fauny skorupiakow galicyjskich-Krakau, 56 pp. 1 pl.
German resumè as Uebersicht der Crustaceen-Fauna Galiziens.
Anz. Akad. Wiss. Krakau, Juni 95, 170-8.
Rev. Z. C., ii, 346-7.
Systematic-faunistic.

WILLE, N.

96. Resultate einer vorläufigen Untersuchung über Organismen in Christiania-Trinkwasser. (Mitth. Biol. Ges. Christ., 17 Okt. 95).
B. C., xvi, 125-6.

WOLCOTT, R. H.

94. The Insecta and Acarina of Lake St. Clair. A Preliminary Report.
Bull. Mich. Fish Comm., 4, 55-6.
Systematic-faunistic.

98. New American Species of the Genus Atax (Fab.) Bruz.
Zool. Bull., i, 279-85, 6 fig; also Studies Zool. Lab. Univ. Nebr., No. 23.
Systematic-faunistic.

WOLTERSTORFF, W.

*96. Die "Zoologische Station" des naturwissenschaftlichen Museums zu Magdeburg.
Blatter f. Aquar. u. Terr. Freunde, vi, 13-5.

WOODWORTH, W. McM.

96. Preliminary report on Collections of Turbellaria from Lake St. Clair and Charlevoix, Michigan.
Bull. Mich. Fish Comm., 6, 94-5.
Faunal list with notes.

96a. Report on the Turbellaria collected by the Michigan State Fish Commission during the Summers of 1893 and 1894.
Bull. Mus. Comp. Zool., xxix, 239-43. 1 pl.

97. On some Turbellaria from Illinois.
Bull. Mus. Comp. Zool., xxxi, 1-16. 1 pl.
Systematic-faunistic study. Valuable bibliography.

YUNG, E.

97. Le Plankton d'eau douce.
La Semaine Littéraire, 97, 519-21.
Popular discussion of methods, investigators and results.

Digitized by Google

ZACHARIAS, O.

93. Forschungsberichte aus der biologischen Station zu Plön.
I. Fauna des grossen Plöner Sees. II. Beschreibungder neuen Formen. III. Biologische Mittheilungen.
Theil 1, Berlin, 52 pp. 1 taf.

93a. Die mikroskopische Organismenswelt des Süsswassers in ihrer Beziehung zur Ernährung der Fische.
B. C., xiii, 155-60; Jahresb. Centr. Fisch. Ver. Schles.-Holstein.

93b. Fauna des Grossen Plöner Sees.
B. C., xiii, 377-82. (From Forsch-ber. Biol. Stn. Plön, i.)
Merely a list of species.

94. Forschungsberichte aus der Biologischen Station zu Plön.
Theil 2, Berlin, vii and 155 pp. 2 taf. 1 landkarte.
Rev. Z. C., i, 215-8.

94a. Faunistische Mittheilungen.
Forsch-ber. Biol. Stn. Plön, ii, 57-90.

94b. Forschungsergebnisse am Grossen Plöner See.
Z. A., xvii, 33-5.
Review of two years work at Plön.

94c. Beobachtungen am Plankton des Grossen Plöner Sees.
Forsch-ber. Biol. Stn. Plön, ii, 91-137.

94d. Ueber die Vertheilung der Planktonorganismen innerhalb eines Sees. (From Forsch-ber. Biol. Stn. Plön, ii.)
B. C,, xiv, 122-8; Trans. Rev. Biol. Nord France, vi, 185-94; Boll. Sci., xvi, 89-92, 113-16; Abstr. J. R. M. S., 94, 552.

94e. Ueber Periodizität und Vermehrung der Planktonwesen.
B. C., xiv, 226-30.

94f. Aus der biologischen Süsswasser-Station am Gullsee in Minnesota.
B. C., xiv, 299-300.
Review of Nachtrieb, 94.

94g. Die biologische Süsswasserstation der Universität von Illinois.
B. C., xiv, 559-60.
Review of Forbes, 94.

94h. Biologische Untersuchungen in amerikanischen Seen.
B. C., xiv, 605-7.
Short review of the work of Reighard and Ward.

94i. Ueber die wechselnde Quantität des Planktons im Grossen Plöner See.
B. C., xiv, 651-6.
Rev. Z. C., i, 786; J. R. M. S., 94, 552.

94k. Das dritte Arbeitsjahr der Biologischen Station zu Plön.
Z. A., xvii, 448.

94l. Statistische Mitteilungen über das Plankton des Grossen Plöner Sees.
Z. A., xvii, 457-61.

Digitized by Google

95. Forschungsberichte aus der Biologischen Station zu Plön. Theil 3. Berlin. 209 pp. 2 pl. 3 tab.
Rev. Z. C., ii, 70-3.

95a. Faunistische Mittheilungen.
Forsch-ber. Biol. Stn. Plön, iii, 73-96. 2 taf.
Description of new species and data regarding known forms.

95b. Ueber die wechselnde Quantität des Plankton im Grossen Plöner See.
Forsch-ber. Biol. Stn. Plon, iii, 97-117.
Based on weighings made regularly from March to September.

95c. Ueber die horizontale und verticale Verbreitung limnetischer Organismen.
Forsch-ber. Biol. Stn. Plon, iii, 118-28.

95d. Fortsetzung der Beobachtungen über die Periodicität der Planktonwesen.
Forsch-ber. Biol. Stn. Plön, iii, 129-44.
Record of daily observations throughout the year.

95e. Statistische Mitteilungen aus der Biologischen Station am Grossen Plöner See. II-XII.
Z. A., xviii, 28-29, 70-1, 87-9, 125-7, 140-2, 190-3, 256-9, 305-8, 367-71, 414-9, 448-52.
Tables of amount and composition of plankton hauls.

*95f. Uber die Ziele und Gesichtspunkte einer wissenschaftlichen Durchforschung der Süsswasserbecken.
Deutsche Fisch. Zeit., xviii, 89-91. (Beilage.)

95g. Ueber den Unterschied in den Aufgaben wandernder und stabilier Süsswasserstationen.
B. C., xv, 378-84.

95h. Ueber den Frühjahrs-Vegetation limnetischer Bacillariaceen im Gr. Plöner See.
B. C., xv, 517-9.

95i. Ueber die vertikale Verteilung limnetischer Crustaceen, insbesondere über diejenige von Cyclops oithonoides.
B. C., xv, 686-8.
Rev. Z. C., iii, 824-5; J. R. M. S., 95, 631.

95k. Ueber die Möglichkeit einer biologischen Bonitierung von Fischteichen.
B. C., xv, 847-8.

*95l. Ueber das Gewicht und die Anzahl mikroskopischer Lebewesen in Binnenseen.
Helios, xiii, 103-5, 113-9. Also in Gaea, 1896, 1, 31-6.

*96. Planktonmessungen im Grossen Plöner See.
Corr. Bl. f. Fischzucht, iii, 7-8.

96a. Sucherokular mit Irisblende.
B. C., xvi, 30-1; also Forsch-ber. Biol. Stn. Plön, iv, 288-90.

Digitized by Google

*96b. Ueber Periodicität und Vermehrung der Planktonwesen.
Zeit. f. Fischerei, ii, 149-53.

96c. Ueber der natürliche Nahrung der jungen Wildfische in Binnenseen.
B. C., xvi, 60-6.

*96d. Orientirungsblätter für Teichwirthe und Fischzüchter.
1. Die naturliche Nahrung der jungen Wildfische in Binnenseen.
2. Verschiedene Mittheilung über das Plankton unserer Seen und Teiche.
Plön, 8°, 12 pp, and 16 pp.

96e. Forschungsberichte aus der Biologischen Station zu Plön.
Theil 4. Berlin. 290 pp. 1 taf. 45 fig. 1 karte.

96f. Quantitative Unterschungen über das Limnoplankton nebst Anleitung zur Vornahme von Zahlungen und Volumenmessungen.
Berlin. 64 pp. From Forsch-ber. Biol. Stn. Plön, iv, 1-64.
Rev. Z. C., iii, 445-7.

96g. Ergebnisse einer biologischen Excursion an die Hochseen des Riesengebirges.
Forsch-ber. Biol. Stn. Plon, iv, 65-87.

96h. Monatsmittel der Plankton-Volumina.
B. C., xvi, 803-6.
Abst. Z. C., iv, 52.

97. Forschungsberichte aus der Biologischen Station zu Plön.
Theil 5. Stuttgart. 180 pp. 4 taf. 1 tab.

97a. Neue Beiträge zur Kenntniss des Süsswasserplanktons.
Forsch-ber. Biol. Stn. Plön, v, 1-9. 1 taf.
Description of new limnetic species.

97b. Biologische Beobachtungen an den Versuchsteichen des Schlesischen Fischereivereins zu Trachenberg.
Forsch-ber. Biol. Stn. Plön, v, 10-28.

97c. Zur Mikrofauna der Sandforter Teiche.
Forsch-ber. Biol. Stn. Plön, v, 112-4. 1 text fig.
List of forms from fish ponds; cf. Lemmermann, 97.

*97d. Leipziger Plankton.
Zeit. f. angew. Mikr., iii, 141-6.

98. Das Heleoplankton.
Z. A., xxi, 24-32; Rev. Z. C., v, 160-1

98a. Das Potamoplankton.
Z. A., xxi, 41-8; Rev. Z. C.,v, 161.

98b. Forschungsberichte aus der Biologischen Station zu Plön.
Theil 6. Abt. 1, Stuttgart. 87 pp. 3 pl.
Rev. B. C., xviii, 299-301.

98c. Summarischer Bericht über die Ergebnisse meiner Riesengebirgsexcursion von 1896.
Forsch-ber. Biol. Stn. Plön, vi, 1-8; Rev. Z. C., v, 353.

98d. Forschungsberichte aus der Biologischen Station zu Plön.
Theil 6. Abt. 2, 87-219. 2 taf. 1 karte.
Rev. B. C., xviii, 718-20.

Digitized by Google

98e. Untersuchungen über das Plankton der Teichgewässer.
Forsch-ber. Biol. Stn. Plön, vi, 89-139. 1 taf.
Rev. Z. C., v, 488-9.

98f. Ueber einige interessante Funde im Plankton sächsischer Fischteiche.
B. C., xviii, 714-8.

98g. Ueber die mikroskopische Fauna und Flora eines im Freien stehenden Taufbeckens.
Z. A., xxi, 670-3.

ZACHARIAS AND LEMMERMANN.

96. Ergebnisse einer biologischen Excursion an die Hochseen und Moorgewässer des Riesengebirges.
Berlin. 80 pp. 26 fig. 1 pl. (From Forsch-ber. Biol. Stn. Plön, iv).
Rev. Z. C., iii, 425-6.

ZEPPELIN, E. VON.

95. Les observations du Dr. Hofer sur le Plancton dans le lac de Constance.
Arch. sci. phys. et nat. Genève, 3, xxxiv, 458-60.
Rev. Z. C., iii, 315.

ZIMMER, C.

98. Ueber tierisches Potamoplankton.
B. C., xviii, 522-4; Rev. Z. C., v, 605; J. R. M. S., 98, 528.

ZOGRAF, N.

95. An Attempt to Explain the Origin of the Fauna of Lakes in European Russia. (Russian).
Bull. Ac. Imp. St. Pet., iii, 2. 19 pp. 1 map.

96. Essai d'explication de l'origine de la faune des lacs de la Russie d' Europe, (Communication preliminaire).
C. R. III. Cong. Int. Zool. Leyde, 183-95. Rev. Z. C., iii. 581-3.

97. What the Hydrobiologic Station on Lake Glubokoe (Deep Lake) Has Done and Ought to do. (Russian).
Arb. Ichth. Sect. K. Russ. Acclim. Ges., ii, 202-6. 1 pl.
Rev. Z. C.. iv, 430-2.

ZSCHOKKE, F.

94. Die Tierwelt der Juraseen.
Rev. Suisse Zool., ii, 349-76. 1 Taf.
Rev. Z. C., i, 737-8 (= Zschokke, 94a); J. R. M. S., 95, 42.

94a. Neuere Arbeiten über die Tierwelt des süssen Wassers.
Z. C., i, 733-8.

95. Die Fauna hochgelegener Gebirgseen (with appendix by Stingelin).
Verh. Naturf. Ges. Basel, xi, 86-133. 1 pl.
Rev. Z. C., ii, 99-102: B. C., xv, 506-17 (= Imhof, 95, q. v.).

95a. Die biologische Station zu Plön nach den Forschungsberichten.
Teil 2 u. 3. B. C., xv, 408-15.

97. Fauna Helvetica. Seenfauna.
Bibl. schweiz. Landeskunde, iv, 6, 24 pp. Rev. Z. C., v, 353-4.
Including references to all forms except insects, from 1680-1897.

Digitized by Google

SUMMARY OF PROGRESS.

Among the general works treating of freshwater subjects the limnologic monograph of Forel easily deserves the foremost place, both by virtue of the breadth of its scope and by reason of the completeness and precision of its treatment. Planned to cover the entire field for a single lake, Geneva in Switzerland, the work is worthy of the magnificent sheet of water with which it deals. It is truly monographic and an indispensable aid to every limnologic enterprise. Thus far but two volumnes have appeared, the first of which (Forel, 92) falls really just without the time limits of this review, yet for completeness calls for mention here. It first deals with the apparatus employed and the plan of the entire work, and then covers the sections on I Geography, II Hydrography, depth, shore, bottom, III Geology, IV Climatology, V Hydrology, sources, outflow, level. The second volume (Forel, 95) handles sections VI Hydraulics, current, movements, *seiches*, waves, VII Thermics, VIII Optics, transparancy, color, mirages, IX Acoustics, X Chemics, density, odor and value as drinking water.

The American student possesses in Russell (95) a valuable discussion of the geologic and physiographic features of North American lakes and lake systems. Lampert (98) has given a semi-popular yet thorough and accurate presentation of life in fresh-water. The larger part of the work is devoted to a systematic and biologic description of the genera which occur in the German waters, but there are also important chapters on the history of freshwater investigation and on general limnologic questions. Apstein has published (96) a convenient and valuable work on the freshwater plankton which presents the extensive investigations of the author on Holstein lakes in comparison with the results achieved by other workers elsewhere. The details of the work are referred to under special topics later in this article. Klunziger (97) has given an admirable review of the methods and results of plankton work, with special reference to the problems of fish culture, and Field (98a) has presented a concise study of the same question.

Digitized by Google

But few bibilographies bearing upon the subject of freshwater investigations have yet been published. That of Dolley (96) is most largely marine, while those of Apstein (96) and Field (98a) are exclusively confined to plankton studies. Others treating of single genera or groups occur in systematic papers on these forms.

The work of Mez (98) is rather of a technical character for use in water analysis and treats of Protozoa alone among animal forms, discussing particularly their relation to the quality of the water and their dependence upon its physical and chemical character. American students are awaiting eagerly a somewhat similar work by Whipple, which is already announced.

Stokes (96) is a convenient summary, largely taxonomic, of freshwater genera; it contains, however, data on apparatus for collecting and notes of a biological character.

In the line of apparatus for special work on limnetic questions much has been done and yet mostly in the direction of adapting that used in marine investigations to the conditions in fresh water. A recent and comprehensive discussion of the former may be found in Hensen (95), whose assistant, Apstein, was the first to apply the same methods to freshwater studies; the latter has given (96) an extended account of the forms of apparatus used in his plankton investigations and somewhat generally applied by others also. Forel (92, 95) mentions numerous pieces of apparatus used in physical, chemical and metereological studies on Lake Geneva. Here also Ule (94). Fric̆ and Vávra's account (94) includes figures of many kinds of smaller collecting appliances, and Klunziger (97) refers in a general way to plankton apparatus. R. H. Ward (95) speaks of the advantages of the Birge net, particularly in shore collecting and among marsh plants.

Of new physical apparatus, the thermophone invented by Warren and Whipple (95, 95a; cf. also Whipple, 95) is undoubtedly the best instrument yet devised for recording water temperatures. See Linsbauer (95) for a method of determining the amount of light at a given depth.

Digitized by Google

The vertical net, planned by Hensen and first used by Apstein in fresh water, is described by the latter (96). Some improvements in detail were made by Reighard (94a) and by Kofoid (97) while the latter adapts the vertical net by an ingenious arrangement to oblique hauls in shallow water. In a later paper (98a) he gives a careful account of the best method for the construction of the vertical net. Vertical closable nets worked by sliding weights are described by Birge (97a) and Marsh (97), and a horizontal net which can be opened and closed by a cord by Lakowitz (96). The former are prompt and accurate in action and may be used at any depth, having been tested up to 130 m., while the latter is apparently cumbersome, if not uncertain in action, and on the authority of the author can be made use of only up to 20 m. in depth. As to the material, fine silk gauze, of which such nets are constructed, Frenzel (97a) makes some criticisms regarding its inconstancy; since while a single haul does not usually close the pores to a noticeable extent there are exceptions, and furthermore continued use is sure to modify its filtering capacity, thereby falsifying all calculations. The pores are closed by accumulated detritus, not by diatoms or other small planktonts. The net should be vigorously washed and wrung out each time to clean out the pores. Hensen (97) questions these statements regarding clogging and objects to such drastic treatment in cleaning the net. Recently Kofoid (97a) has attacked the accuracy of results obtained by the vertical net on the opposite basis: that it allows the escape of too many organisms since "the silk retains from 5 per cent. to less than 0.1 per cent of the total *number* of organisms present excluding bacteria, as contrasted with the catch of the Berkefeld filter;" volumetrically the catch equals from one-half to only one forty-fifth of the amount actually present in the water. Reighard (98) calls attention to the fact that the larger size of the nets used by some observers makes clogging a less important factor than in studying silt-laden waters with a small net. Shrinkage being largely if not entirely eliminated by previous treatment of the net, leakage is

Digitized by Google

the only uncertain factor, and since the organisms which escape thus are the smallest, their volumetric importance may be slight; but they must be investigated numerically by other methods as the numerical estimations made from catches of the vertical net are evidently most open to question.

As the vertical net does not collect all the material in the column of water through which it passes, various means have been adopted to ascertain the portion of water actually strained or the coefficient of the net. Hensen's earlier, extremely complicated method was pointed out by Reighard (94a) and Ward (96b) to be open to question, and the former proposed an experimental method (94b) for precise determination of the efficiency of the net. Hensen (95) advocates the use of a tin plate covering the mouth of the net except a small opening in the center. By counting the number of individuals of a well marked species caught under these conditions and comparing with the number caught by the full opening of the net, its coefficient may easily be obtained. The method, however, evidently affords more opportunity for error than that proposed by Birge (97a) who filtered the entire column of water in a tin cylinder having the diameter of the net opening in order to ascertain the coefficient of the net. This was found to be about two, and the difference between maximum and minimum hauls of the net was no greater than that shown by the column of water in the cylinder at sucessive tests.

For Crustacea alone Birge found that the clogging of the net in an 18 m. haul did not markedly affect its coefficient over that employed for the 3 m. haul until after the rapid increase of the phytoplankton in July. For the short haul the clogging made at no time any visible alteration in the coefficient which in the opinion of Birge is furthermore one of the most constant factors, and quite as accurately determined as any other. However, Frenzel (97a) is inclined to think the coefficient decidedly variable. Kofoid (97a) ascertained the coefficient of the net in use at the Illinois station, according to the original method of Hensen, to be 1.32; experimentally it was shown to vary

Digitized by Google

from 1.5 to 5.7, where the greatest variation is largely due to the clogging of the net by heavy plankton hauls. Reighard (98) proposed to eliminate all of the difficulties connected with clogging, shrinkage and net coefficient at once by measuring the volume of water that actually passes through the net in each haul. To this end a small current meter is to be placed in the mouth of the net and the volume calculated from the rate of the current passing through the opening. Experiments in this direction are now in progress.

As a substitute for the vertical net in obtaining the plankton from a certain quantity of water, several investigators experimented almost simultaneously with a plankton pump, so constructed that a definite amount of water is delivered by a single stroke, the depth from which it comes being regulated by the position of the mouth of the attached hose. The greatest difficulty which presents itself is the proper filtration of the water discharged from the pump. The advantages urged in its favor are (Kofoid, 97) greater accuracy in determining the volume strained, the wide applicability of the method in shallow water, in currents, under ice, amid vegetation, for water very rich or very poor in plankton, and the rapidity of the process. The pump used by Kofoid was very large. Frenzel (97) who advances much the same arguments in favor of this apparatus, which he used with particular success in obtaining plankton under the ice, gives no particulars regarding his pump. Fordyce (98) describes a pump which is easily portable and can be used with advantage in small bodies of water.

A centrifugal apparatus has been used with success by Juday and Kofoid (97) on preserved material in the measurement of plankton volumes. Dolley (96) has employed a larger form, called by him the planktonokrit, in the precipitation and measurement of living plankton. This machine has been used by Field (98) who later (98a) maintains its great superiority for volumetric estimation over all other methods yet discovered. Jackson (96, 98) found, however, that while good results were obtained with Infusoria and Rotatoria, the reverse

Digitized by Google

was true if Cyanophyceae were present, as these are not thoroughly precipitated owing to low specific gravity. The material is also matted together, preventing equal distribution on the slide if numerical estimation is to be employed. Kofoid (97a) emphasizes the selective error of the centrifuge on living plankton.

In microscopical water analysis for technical purposes the Sedgwick-Rafter method almost universally employed has been subject to modification in detail by Jackson (96, 98), while Whipple (96) has analyzed most clearly the various errors of the method and the value of each. The same author has also (97) planned a simple form of apparatus for water analysis. Leeds gives a valuable discussion and summary of these methods.

In the filtration of plankton organisms Kofoid (97a) found that the sand filter retained only 40 to 65 per cent of the number of organisms present and advocated as more satisfactory and precise the Berkefeld filter. Reighard (98) objects to the contamination of the plankton resulting from the use of the latter, and Jackson (98) considers that the slow rate of filtration makes its use entirely unpractical.

For the manipulations connected with the enumeration of individuals in plankton hauls various minor pieces of apparatus have been suggested; only the more important need be noticed here. Whipple (94b) advised the employment of an ocular with a field suitably ruled, and Zacharias (96a) introduced an ocular of large field with an iris diaphragm. As the enumeration of organisms recorded without reference to size and character is extremely misleading, Whipple (94b) proposed a standard unit of size, 20x20 microns, as a means of correcting the error. Tables for common organisms and an ocular with ruled field assist in the computation. Comparison of lines platted to show the numerical and areal values of the organisms in a haul with the albuminoid ammonia curve for the same demonstrate the much closer correspondence of the areal estimation with the amount of organic substance present. By the use of logarith-

Digitized by Google

mically ruled paper Scourfield (97a) was able to represent extreme ranges in number of organisms while at the same time proportionate changes in number are indicated by lines having the same angle of slope in whatever part of the chart they may be situated.

The freshwater stations of the world have not all been founded within the last five years. Yet only the Swiss and Bohemian stations can be said really to antedate this, and even then much of their important work comes within this period. As to what constitutes a "station" and what each has accomplished I have spoken in another place,* and shall refer here only briefly to such articles concerning the origin, management and functions of those formal enterprises as would not easily be included under other headings. A general account of such institutions is given by Lampert (98), and for America by Kofoid (98b). Scourfield's appeal (96, 97) for the foundation of a British station, and Fric's presentation (97) of Europe's example contrast well the position of the two countries in this movement.

The oldest definite station in Europe, the Bohemian, is described in Fric and Vávra (94, 97). The Plön station and its opportunities are set forth in Klunziger (96), Zacharias (93, 94, et alia), Zschokke (95a). Other German stations are noted by Woltersdorff (96), Frenzel (95). In Hungary, Entz (97), and in Russia Zograf (97) record similar enterprises. In Italy Garbini's long and successful investigations on Lake Garda entitle that station to a high rank. In North America work on the Great Lakes is recorded by Reighard (93), on Lake Mendota by Birge (95, 97), on Gull Lake, Minn., by McMillan (93), Nachtrieb (94), Zacharias (94b), and on Turkey Lake by Eigenmann (95). The work of the Illinois station at Havana, the most extensive American enterprise of this character thus far, is fully set forth in the reports of the director (Forbes, 94, 97) which are inspiring appeals to limnobiologic investigation. Other references to this station are Kofoid (96a), Ross (97b)

* Science, n. s., ix, 497-508.

Digitized by Google

Zacharias (94g). The technical station of the Boston water works is well described by Whipple (97b) who sets forth clearly the importance of such an enterprise in its relation to the water supply of a great city.

Last year the United States Fish Commission made a preliminary survey of the region about Put-in-Bay, Lake Erie, with reference to the fitness of this point for an experiment station in connection with the government fish hatchery. The work will be continued the coming summer (H. M. Smith, 98.) The necessity for an aquacultural experiment station, the right of such a foundation to governmental support, its proper location and function and allied questions are discussed by Ward (98a). Zacharias (95g) believes that a wandering lacustrine station is of secondary importance; some evidence to the contrary could be found in the work of Fric̆ and Vávra (94, 97), Reighard (94), Ward (96b).

The temperature conditions of freshwater lakes were discussed by Fitz Gerald (95). In temperate climates, deep lakes show a winter curve running from 0° C at the surface to 4° C at the bottom, while the summer curve is reversed, extending from 24° C at the top to 7°–10° C at the bottom. Whipple (95a) shows that a temperature difference of 3° C prevents wind from maintaining circulation and the lower region remains stagnant until the fall overturning mixes the water of the lake. Birge (97a) made a most careful study of the temperature conditions and variations in Lake Mendota. The warming of the water in the spring is gradual and uniform until the difference between top and bottom is 7°–8° C. Then gentle winds with high temperature lead to the formation of a mass of warm water on the surface so thick that however the wind may blow there is always a warm stratum floating on the colder water. Immediately below the warm water is a layer a meter or less in thickness in which the temperature falls very rapidly; this layer Birge names the thermocline. Below it the temperature falls gradually to the bottom of the lake. Once formed, late in June, at about eight meters of depth, it moves downward slowly and

Digitized by Google

irregularly, depending upon the action of the wind, and reaching the bottom as a result of the late September gales, disappears. These conditions are of extreme biological importance since below the thermocline the water is stagnant during the entire summer and becomes unfit to support most forms of animal life. The sub-thermoclinal water is reported by Whipple (95a) and others to be malodorous, deficient in oxygen and rich in the products of decay. Its overturning is the occasion of a rapid increase in the diatoms of the plankton.

Whipple (98) distinguishes three types of lakes, polar, temperate and tropical, according to the surface temperature, which in lakes of the first type is never above that of maximum density (4° C), in those of the tropical type never below that point, and in lakes of the temperate type sometimes above and sometimes below it. He also designates three orders of lakes on the basis of the bottom temperature, which in those of the first order is practically constant at or near the point of maximum density; in those of the second order the bottom temperature fluctuates but never very far from the same point while in lakes of the third order the bottom temperature rarely varies from that of the surface. With regards to periods of circulation which are so important for the development and distribution of the plankton, he says: "Speaking in very general terms, we may say that lakes of the first order have no circulation; lakes of the third order no stagnation (except in winter); and lakes of the second order have both circulation and stagnation." According to Birge (98) the thickness of the surface stratum of warm water depends on the wind, the exposure of the lake, and among those similarly located in these particulars, upon the area of the lake, being less in a lake of smaller area. The bottom temperature of a small lake is likely to be lower than one would expect from the depth merely and that of a large lake higher. Here also Ule (93), Langenbeck (93) and Dolan.

The amount of oxygen present in various parts of a water basin and the dissemination of gases through the water is of

Digitized by Google

the greatest importance in its bearing on conditions of existence in a lake. Drown (93) found that in water basins in winter under the ice there is a deficiency in the amount of oxygen present, which increases from the surface downward. In some reservoirs the bottom water becomes even malodorous and as poor in quality as during the summer stagnation period. This was true only of lakes rich in organic material. The careful and extended investigations of Hoppe-Seyler (96) on Lake Constance, Switzerland, show a deficit of oxygen in deeper waters above the calculated amount. The amount present, however, is still sufficient to satisfy the respiratory needs of the abyssal animals, even the most sensitive fish, such as trout. Knauthe (98) maintains that in somewhat turbid waters the micro-organisms demand more oxygen than fish and larger forms and in stagnant waters far more than is contributed by the atmosphere. In daylight the microscopic green plants give off oxygen to the water so abundantly that in strong sunlight the maximum is reached in a few hours. Even moonlight causes an appreciable increase in the quantity of oxoygen; but in darkness the amount sinks in five or six hours of summer temperature to the minimum necessary for the Cyprinidae.

Calkins (93) groups the odors of freshwater into three classes (1) those of chemical or putrefactive decomposition, (2) those of growth, i. e., excretory products, and (3) those of physical disintegration. All evidence points to oil globules as the specific cause of those odors grouped under the last two classes. Certain odors are associated with definite organisms. Jackson and Ellms (97) were able to add to the evidence concerning natural odors and the organisms producing them and to distinguish sharply between the natural odor and that produced by the decomposition of the same organism. Here also Whipple (94a).

The geological and physical features of individual lakes have been studied by Ule (94a) at Plön, Pero (95) in Italy, Large (97) in Indiana, Wagner (97) in Bohemia, and Lorenz von Liburnau (98).

Among the articles noted on the phytoplankton Schröter (97)

Digitized by Google

presents the most general survey of plant life in the water. He distinguishes by the vegetation three general types of water basins, swamp, pond and lake; the swamp plants rise with vegetative organs above and free from the surface of the water. In the pond true submerged plants are wanting and only submersed plants with swimming leaves and submersed plants with emersed leaves are normally present. To the single plankton organism the term planktont is applied and among the lake plants the author differentiates (1) the floating flora, or phytoplankton with the eulimnetic species of the open water, the bathy-limnetic forms, half floating, half inhabitants of the littoral zone, and the tycho-limnetic plants, stray elements of shore or bottom flora; (2) the swimming flora, pleuston, driven about on the surface and with organs fitted to an aerial existence; (3), the bottom flora or phyto-benthos, bound to the substratum and consisting of flowering plants, Characeae, sessile algae and mosses, epiphytic and endophytic algae, and fungi and bacteria. Each individual body of water has its own characteristic flora as is shown by comparison of a series of lakes. A careful study of the plankton shows numerous adaptations to the conditions of its existence.

These general principles are repeated and emphasized by examples in the general part of Schröter and Kirchner (96) which deals with the flora of Lake Constance based upon about five years of study. The special discussion of the algal flora of the lake by the second author includes an account of characteristic features and of the composition of each part of the flora. There were found in the lake the very large number of 361 separate species. No quantitative investigations were made on the plankton. Here also Bruyant (94) and Magnin (95).

Among the Cyanophyceae Strodtmann (95, 95a) and Klebahn (96, 97) find in the so-called "red bodies" the cause of floating. So long as these are present in sufficient numbers the algae swim at the surface, when they are scanty or wanting the algae sink slowly or rapidly to the bottom. The "red

Digitized by Google

bodies " are actually gas vacuoles in the protoplasm, present in all the plankton Cyanophyceae, but entirely wanting in the fixed forms.

On the diatoms of the plankton Zacharias (95h) gives statistical records from the enumeration of plankton hauls during the year showing the number found at different seasons and the maxima and minima of various species. Whipple (94) notes the effect of the fall overturning of the water in producing a maximum of diatom development by the distribution of an abundant food supply from the stagnant substratum of the water. In a later paper (96a) are recorded more detailed observations on the effect produced by other causes. The maximum of diatom growth is shown experimentally to be just below the surface of the lake, to be greater in light-colored water and to vary in close correspondence to the variation in the intensity of the light. Apparently the diatoms possess no power to move upward toward the light but are carried upward by convection currents in the water. Such conditions prevail particularly in the fall circulation period. Pero has studied very carefully the distribution of the diatoms in the lakes of a single canton in the Alps.

The "water bloom" has been studied by Klebahn (96) who finds that thirteen different species may give rise to the phenomenon. According to Strodtmann (98) it is only indirectly the cause of actual damage, varying in amount under different conditions, and is of direct value as food, particularly to the Cladocera and Copepoda which are so important as fish food. Here also Richter (94) and Thomas (97). Seligo (97) discusses the damage done by the introduced *Elodea canadensis* and believes it probably overdrawn. After considering its relation to the general biology of the water, the author emphasizes the small value of the shore plants in the food relations of freshwater and yet on the other hand the known greater abundance of fish where such plants are found.

For Plön and other lakes in Holstein, Klebahn (95) describes the aquatic vegetation, the regions into which it may be di-

Digitized by Google

vided and the forms in each. Here also Lemmermann (95, 96a). Lemmermnan (96), Müller (98) and Schröder (98) report on the flora of the lakes in the Riesengebirge, and the latter undertakes to distinguish the formations of the freshwater algae, as limnophilous, potamophilous, sphagnophilous crenophilous, geophilous, lithophilous and kryophilous, giving faunal data regarding each. Concerning other local floras there is noted the report of Pieters (94) on that of Lake St. Clair, Thompson (96) on Lake Michigan and Whipple, Jelliffe and others on the flora of city water supplies in this country.

On the flora of ponds used for fish culture Lemmermann (97) and Schröder (97) have made some investigations. The former reaches certain preliminary conclusions as to the economic worth in such ponds of different forms of vegetation.

The freshwater fauna may be considered from two main standpoints which indicate thus principal subdivisions of the subject. One may investigate the forms of which it is constituted or the location in which these forms are found, discussing accordingly first their composition and second their distribution.

Regarding the composition of the freshwater fauna it may be said that nearly every paper listed in the bibliography contributes some notes of importance. Under this heading, however, it is the intention to bring together briefly only those which for one reason or another lay particular emphasis on this feature, dealing with taxonomic groups of various size in their faunal relations. As noted previously the bibliography makes no claim to completeness on extra-plankton topics. Its shortcomings are undoubtedly most noticeable under the present heading. Greater attention has naturally been devoted to contributions treating of North American forms while literature on freshwater vertebrates has been entirely omitted, and that on insects almost wholly.

On Protozoa Blochmann presents a very satisfactory general summary. Schewiakoff (93a) is the most important contribution on the group within the limits of this review. In Europe Levander (94a), Entz (96), Francé (97), deal with the protozoan

Digitized by Google

fauna of a single region; similarly F. Smith, Kofoid (96) J. C. Smith and Hempel in this country. Here also Garbini (94a), Butschinsky. Among papers dealing with one or more subdivisions of the group may be noted Schaudinn, Frenzel (97b), Schewiakoff (93), Seligo (93), Švec and Francé (97a). On the Porifera Weltner (95), Hanitsch and Vángel (97).

Fuhrmann (94), Borelli, Szigethy, Vejdovsky, Volz and Woodworth have contributed to a knowledge of the Turbellaria, while Böhmig and Montgomery deal with the Nemertines. The results of Daday's work (97a), on Balaton Nematodes make one wonder whether these free living forms have not been much neglected heretofore.

On the Rotatoria, a most important plankton group, there has appeared the recent valuable memoir of Weber. Wierzejski (93), Levander (94b) and Daday (97b) have contributed to a knowledge of the group in Europe, and Kellicott, Jennings and Hempel in the United States. Here also Eckstein, Garbini (95a), Kertész and Hood. Imhof (95a) and Walker treat of the Mollusca in connection with freshwater investigations. Call discusses the relation of the molluscan fauna to different hydrographic basins in a region belonging to several drainage areas.

The splendid monograph of Piersig and the papers of Koenike, Daday (97d) and Wolcott (98), together with briefer articles by Soar and Nordenskiöld comprise the studies on Hydrachnids listed. On the entomology of a freshwater body the work of Hart easily takes the first place; articles by Klapálek, Wolcott (94), and Garbini (95d) are also noted.

Among the articles on the Crustacea, those of Garbini (95c) and Wierzejski (95) are general in their scope. The Entomostraca have been studied by a host of investigators, among whom may be noted Daday, de Guerne, Herrick, Mrázek, Poppe, Richard, Rizzardi, Sars, Scott, Scourfield, Steuer, Turner, Vávra and Wesenberg-Lund. On the Ostracoda particularly are noted the works of Brady and Norman, Vávra, and in this country Turner and Sharpe.

The magnificent monograph of Schmeil on the Copepoda

Digitized by Google

deserves prominent notice. Valuable articles on the group are Mrázek, Marsh (95), E. B. Forbes, Schacht and Brewer · On the Cladocera the revision of Richard (94, 96) is a model of completeness and accuracy. Birge (93, 94), Ross (96), Turner (93) in this country, and Stenroos (95, 97), Stingelin (95), Weltner (96) in Europe, have contributed to a study of the same group. On all of the plankton crustaceans much emphasis has been laid and in most of the articles noted under the head of distribution may be found important taxonomic notes on these groups.

The distribution of freshwater life may be regarded from the standpoint of the single body of water or through a comparative view of different bodies of water. In the latter case one may consider those bodies which · are within a given geographic area, or those which are associated in character. Accordingly it is permissible to speak of the geographic, the hydrographic and the areal distribution of freshwater organisms. In considering first the geographic distribution of freshwater animals, regions are designated by ordinary geographic terms since a basis for subdivisions into faunal regions has not yet been worked out save in Russia by Zograf. Of general value on the geographic distribution of freshwater animals is the work of Schewiakoff (93a) on the Protozoa which seems to indicate a cosmopolitan distribution for these forms. Frenzel (97b) doubts this on the basis of studies in South America, since of 88 species found in Argentina, 44 are new. The accuracy of these studies has, however, been questioned.

Observations on Australian forms are reported by Chilton and Sars, from the Pacific Islands (Samoa) by Krämer, from Sumatra by Richard (94c) and from Ceylon by Poppe (95b) and Daday (98). From eastern Asia Richard (94b) is the only record of the freshwater fauna noted. From Asia Minor Barrois (94) and Richard (95, 96c) complete the list.

Northern Africa is touched upon in Barrois (93) and Richard (93). German East Africa has a well planned biological survey of governmental character in progress. Reports touch-

Digitized by Google

ing upon this topic are Mrázek (95), Weltner (96) and Vávra (97). Poppe and Mrázek (95) treat of nearly the same territory and Weber (97) deals with African faunal regions based on a study of the fishes, decapod crustaceans and mollusks. The work of Moore in Central Africa is considered under the fauna relicta. Concerning island faunas Barrois (96) and Richard (96b) report from the Azores and Richard (98) from the Canaries. The species are mostly cosmopolitan or known from adjacent portions of Africa and Europe.

Single brief reports characterize also our knowledge of the South American freshwater fauna, from the west Borelli, from the east Dahl, Ihering, Frenzel (97b) and Richard (97b), and from the south Vávra (98), with a single note on South Georgia from Poppe and Mrázek (95a).

In Europe extreme northern points are noted in Richard (98a), Scourfield (97b) and Wesenberg-Lund (94). Lauterborn (94a) on the fauna of Helgoland, Scott and Duthie on that of the Shetland Islands, Scott on Scotland, Western, Scourfield and Soar on England and Wales, and Hanitsch and Hood on Ireland, record the advance in knowledge from these regions. From Norway, Wille and Huitfeldt-Kaas, and from Finland, Levander, Nordenskiöld and Stenroos are noted.

From Germany, Schmeil, Piersig, Lampert (98) and Apstein (96) are of general import; more limited in area is the work of Zacharias, Apstein (93) and others from Holstein; Hartwig, Frenzel and others from Central Germany; Lauterborn from the Rhine; Lameere from Belgium; Klápalek, Švec, and Fric and Vávra from Bohemia; Jaworowski and Wierzejski (93, 95) from Galicia; Daday, Entz, Francé, Vángel, and others from Hungary; Schmeil (93a, 94), Lorenzi, Steuer and Richard (96a) from the eastern Alps, and Vávra (93) and Richard (97) from Bulgaria and Albania. The Russian articles, probably exceedingly incompletely recorded, are Zograf (96) and Butschinsky (96).

No region has been more carefully studied than Switzerland and the Alps. The work of Imhof (95a) and especially of

Digitized by Google

Zschokke (95) and of his students and associates Stingelin, Fuhrmann and others, is of great value. On the northern slope of the mountains Hofer, Heuscher and Steck, toward the west and south and in the Jura Forel, Blanc, Pitard, Studer, Weber, de Guerne et Richard, Blanchard et Richard and Pugnat. On the south of the Alpine chain, Garbini, Pero, Fuhrmann (95), Klunzinger (97a), Wagner (97a); in Italy, Rizzardi and Garbini, and in Portugal, Nobre and de Guerne et Richard (96) are among those noted in the list.

On this continent the work of E. B. Forbes, Herrick and Turner, Schacht, Sharpe, Turner (94) and Wolcott (98) is general in extent. On the freshwater fauna of Canada are noted Koenike and Ross (97); on that of the Atlantic coast region Montgomery, Calkins, Whipple, and others; on that of the Great Lakes and contiguous territory, Birge, Jennings, Kellicott, Kofoid (96), Marsh, Reighard, F. Smith, Walker, Ward (94, 96a), Wolcott (94) and Woodworth (96); on the freshwater fauna of the central region Eigenmann, Hart, Hempel, Kofoid (96b, 98), Woodworth (97), and others; further south Herrick (95), Turner (94) and Seurat; on the plains toward the west Brewer and Ward (98); in the mountains S. A. Forbes (93), and on the island of Hayti, Richard (95a) record the work of the period under consideration.

Viewed from the hydrographic standpoint, freshwater organisms may be discussed with reference to the particular environments which each type of water basin affords; one may distinguish roughly the brook, river, swamp, pond and lake as types of environment. These have been very unequally studied as accords with the difficulty and probable results of the investigation. Stockmayer (94) has given a brief summary of the general biologic aspect of the life of the brook, or in fact of water in general, and of the problems to be solved by a station located in a region rich in brooks; such a station is certainly a great desideratum in freshwater work. No record appears of work done on such a body of water.

The importance of studies on a river have been emphasized

Digitized by Google

by Forbes (94, 97) and the particular problems with which one has to deal in such a location. Under the direction of the same investigator there has been opened on the Illinois River a station which is devoted primarily to the problems of a river system. Some of the results are given in the papers of Hart, Hempel and Kofoid. Lauterborn (93, 94) and others have done some work on the fauna of a river, and recently the topic has received more attention. Schröder (97a, 98a) finds in rivers the phytoplankton much in excess, the diatoms constituting the ruling forms. In shallow ponds with not too strong an inflow the zooplankton is far richer than in streams where it decreases with increasing current. Zacharias (98a) shows that the potamoplankton is formed in plant-grown bays on the river shore, and multiplies perhaps in slow-flowing streams. Zimmer (98) finds that the character of the potamoplankton varies with the hight of the water. He distinguishes (1) autopotamic forms which find their conditions of existence only in flowing water. These include at most very few animals. (2) Eupotamic forms, living either in standing or flowing water, including most species of the river plankton. (3) Tychopotamic forms, torn by chance from quiet waters in which they live normally, and finding no possibility of reproduction in the current. The potamoplankton is very poor both in species and individuals as compared with the limnoplankton. The Rotatoria constitute its chief element, adult Crustacea are rare, and only one protozoon has been observed. It is interesting to note that in a lake of the Jura, Zschokke (94) records that the variations of level and the strong current give it partly the character of a river. Here the littoral zone is almost barren but the limnetic fauna rich in species though poor in number of individuals.

No specific report is on record during this period concerning the investigation of a swamp. The closest resemblance to such conditions are presented by Lake Nurmijärvi (Stenroos, 98) which possesses in fact a maximum depth of one meter. Here could be distinguished nevertheless the characteristic regions of the pond or lake fauna. The extreme richness of such

Digitized by Google

shallow bodies of water is indicated by a total of 460 species recorded from this lake. The paper contains most valuable observations on the characteristic fauna in each floristic region and on its structural and ecological peculiarities. Zacharias (98) calls the floating fauna of shallow natural or artificial water basins the *heleoplankton* and has studied it from a number of places. The majority of limnetic forms recur here and certain Rotifera rare or lacking in lakes are found in such basins. Characteristic is also the abundant development of the microphyta and of the Ceriodaphniae. Here also Bigney and Pitard (97a). Fric̆ and Vávra (94) treat of two ponds, of somewhat different character, and give a complete and clear picture of pond life, and the changes it undergoes. Here also Ward (98). The characters of a pond are precisely stated by Zacharias (98) who has found in such water basins almost all the eulimnetic organisms of true lakes. The Rotatoria are more numerous, and in the phytoplankton the desmids are the chief factor.

On the fauna of a lake many investigations have been made within the past five years, and the profitless preparation of mere faunal lists seems fortunately to have passed its maximum since an increasing number of the later papers has considered not merely the composition of the freshwater fauna or of one of its groups, in the region studied, but also the biological relations and the origin of the fauna. Among the large number of lacustrine investigations of all degrees of completeness, only the more extensive can be mentioned in this connection. The monographic work of Forel on Laka Geneva, Switzerland, has already been sufficiently characterized. Lake Plön, Holstein, has also been extensively studied by Zacharias and his coadjutors. Garbini's careful investigations on Lake Garda, Italy, and those of Entz and his confréres on Lake Balaton, Hungary, are also deserving of prominent mention. Schwarzsee, Bohemia, under Fric̆, Müggleseе, Germany, under Frenzel, and numerous other individual lakes in Europe have been subjected to careful investigation with valuable results. In North America Reighard has studied Lake St. Clair, Eigenmann Turkey Lake and Ward the northern portion of Lake Michigan

Digitized by Google

in conjunction with numerous colaborers. Birge has devoted himself singly to Lake Mendota and Marsh to Green Lake.

Other investigators have turned their attention toward a series of lakes or a given type of lake rather than toward a single body of water. Thus Apstein (94) has achieved valuable results from the study of Holstein lakes, Pero has devoted himself to Swiss lakes in a single canton and Hartwig to those of Brandenburg. But the most striking instance of this specialization is Zschokke whose investigations on elevated lakes have established so clearly the biological features of such locations that subsequent studies have added only details to the general picture he has painted. The results of this author are summarized in a final paper (95) which presents further a comparison of the author's work with that already achieved in other regions. This paper includes a careful study of two lake regions in the Alps, a group of small sub-nival bodies of water in the Rhaeticon chain and numerous lakes of Wallis near St. Bernard. Both a littoral and a limnetic fauna is present and in them most freshwater groups are represented, though in European nival and subnival lakes Helizoa, sponges, *Bosmina*, Isopoda and Decapoda are wanting and mollusks are scantily represented. The bulk of the Alpine freshwater fauna consists of resistent cosmopolitan species which recur in part in lakes of high altitude elsewhere. To these are added (1) here and there rare forms from the plains, (2) pure mountain forms often of northern character, (3) abyssal inhabitants of sub-alpine lakes which find a suitable environment on the shores of elevated Alpine lakes. The composition of the lacustrine fauna varies from place to place even within a single mountain chain, but in general unfavorable environment increases with the altitude. The limit of suitable environment, i. e. the upper limit of animal life, lies at different altitudes in different mountain ranges, but appears to be higher in massive ranges than in neighboring chains of lesser magnitude. The presence of certain forms adapted to the particular locality and the absence of other species imparts to the scanty fauna of a mountain lake a decided individuality, often

Digitized by Google

apparently in strong contrast to that of a neighboring basin.

In an earlier paper (94) Zschokke presented the results of studies on lakes in the Jura showing a typical mountain character. Previously de Guerne et Richard (93) had investigated the limnetic fauna in the same region and (94) in the Pyrenees. In the Cottian Alps Blanchard et Richard (97) found similar faunal conditions. Here also Blanc, Pitard, Imhof (93), Pugnat (97). The varying fauna in adjacent basins is explained by the last mentioned author on the ground of variation in the exposure and illumination of the water. Studer (93) attributed the poverty of the limnofauna in the lake of Champex to the excessive illumination of the shallow water in the absence of shore and bottom plants. Imhof (95a) investigated the horizontal and vertical distribution of the aquatic mollusca in the Alps. They are more numerous in the territory of the Rhone and the Po, and manifest in small and in elevated lakes a rapid reduction in number. On the southern slope of the Alps Fuhrmann (95) finds the fauna of the elevated lakes similar, though somewhat richer. In the Julian Alps Lorenzi (97) finds a cosmopolitan fauna in which the plankton consists of tychopelagic forms alone. In the Riesengebirge according to Zacharias (96g, 98c) the limnetic fauna is scanty but similar to that of the Rhaeticon lakes studied by Zschokke. The species present are typical cold water forms. The same poverty and cosmopolitan cast in the fauna is reported by Fric̆ and Vávra (97) who attribute the scanty shore and bottom fauna to the lack of vegetation. The disappearance of certain elements in the fauna can be traced definitely to the introduction of game fish. In the Tatra lakes, Galicia, Wierzejski (95) found typical Alpine conditions in the poverty of species in the abundance of cosmopolitan forms and in the contrast in proximate basins of equal altitude. The lakes show, however, as Daday (97) remarks, notable richness of fauna even up to an altitude of 2,000 m. Here also Richard (96a, 96c). In Syria Barrois (94) found an unusually rich limnetic fauna of cosmopolitan Entomostraca and Rotatoria. The Sea of Tiberius, though strongly saline, has a pure lacustrine fauna.

Digitized by Google

One of the earliest investigations on elevated lake regions and the only one yet made in this country is that of Forbes (93) in Wyoming and Montana. Noteworthy is the careful study of the entire environment and its influence on the fauna. In this Forbes made valuable contributions to the general character of the fauna of elevated lakes which were utilized by Zschokke in the paper already noted. Among the features discussed by Forbes are the extreme poverty of the vertebrate aquatic fauna, the ruling species being rather Amphipods, leeches and insect larvæ, great rarity of mollusks, the abundance of Entomostraca, largely cosmopolitan species, and the sharp contrast of the fauna in adjacent water basins. There exists a deepwater fauna in many of these lakes, of which something was ascertained. In general the fauna proved to be richer than that of lakes at corresponding and even less elevation in Europe. The influence of environment was well shown by variations in the fauna, such as the abundance of mollusks in a lake lying within a lime formation and their rarity in all other elevated waters.

Only one investigator has yet endeavored to group into regions in accordance with their fauna, the lakes of any continental area. Zograf (96) divides the lakes of Russia into four regions, based upon the distribution of the fish and crustaceans. The first region includes the large water basins in the northwestern portion of Russia, the second surrounds the first, the third includes the lakes of Central Russia and is little known, and the fourth takes in the steppe lakes bordering upon the south. Geological evidence supports this general classification, the first three being in territory covered by glacial sheets in different periods and the last constitutes the remains of a miocene sea covering southern Russia.

In discussing the distribution of the fauna within a single body of water authors have regularly adopted Forel's lacustrine regions and the majority have also made use of the terms introduced by Pavesi to designate the plankton organisms as eulimnetic or regular inhabitants of the open lake and tycholimnetic or chance members of the same region. The

Digitized by Google

general composition of the plankton may be judged from the statement of Strodtmann (96) that about 80 organisms occur in the plankton of Holstein lakes of which, however, less than 40 are usual or important. All authors agree in noting the limited number of species which are found in the plankton and equally regarding the extreme abundance of individuals which make up its volume. These organisms, moreover, are not at all times the same species but manifest certain variations to be noted later. Among the species of animals which the plankton contains the Rotatoria are said to be the most important.

The total amount of plankton taken in the vertical net or plankton pump and preserved in some suitable fluid is estimated in several ways. (1) After settling in graduated tubes for twenty-four hours the volume is read off from the tube, Apstein (94), Reighard (94), Ward (96). Or the volume is measured in a centrifugal machine, Juday (97). (2) Under suitable precautions the entire amount is weighed, Fric̆ and Vávra (94), Zacharias (95, 95b). Or a known quantity of a haul, measured by the first method, is taken, weighed both before and after incineration, and the amount of organic material in the entire haul calculated, Ward (96a). (3) The organisms in a definite portion of a haul are counted under suitable precautions and the number of organisms in the entire haul calculated therefrom. This method, first used by Hensen in the ocean, has been applied to freshwater by Apstein (94, 96). Zacharias (94d) employed it in abbreviated form. Another simplified form is given by Birge (95a).

There is no known relation between the results obtained by these different methods and consequently no comparison can be made between the results obtained by one method and those obtained by another. Furthermore while the work of one observer at a given time is capable of comparison with that done at another, it seems perfectly clear that the work done by one observer can not be directly compared with that done by another even if the same method is employed. Difficulties in this connection are noted by Kofoid (97), Reighard (98) and others.

Digitized by Google

Apstein (94) would divide lakes into two classes, plankton rich and plankton poor, the first characterized by an abundance of *Clathrocystis* and absence or rarity of *Dinobryon*, and the second by reverse conditions. This classification is questioned Reighard (94), Zacharias (94) and Strodtmann (96) on the basis of investigations in other lakes. The total amount of plankton is believed by Steck (93) to depend on the length of the shore line, and Reighard (94) also regards this as an important factor. Many observers have noted that there is in general proportionally less in a larger than in a smaller lake, and this has been found by Reighard (94a), Hofer (95), Walter (95), Zacharias (95b), Strodtmann (96) and others to be capable of more precise statement in the principle that the amount of plankton per cubic meter of water varies inversely as the depth. Other factors affect the development of the plankton, chief among them being light, (Stenroos, 98), transparency of the water, (Steck, 93), and temperature, (Zschokke, 95). Walter (95) emphasizes also the relation between the depth and the area of the lake.

In Norwegian lakes presenting a great variety of conditions as to altitude, depth and rapidity of change in water contained therein, Huitfelt-Kaas was able to show that shallow waters are especially favorable for the development of the plankton while deep basins are under otherwise like conditions notably poorer. This is true only in summer and is probably controlled largely by temperature conditions. Even more important, however, is the drainage area of the lake and the proportionate inflow and outflow, so that in basins with rapid change in water much less plankton is found than in more stable lakes. Here it is evident that a shallow lake may be even less favorable for the development of the plankton than a deeper one by virtue of the greater instability associated with a limited volume.

On the question of horizontal distribution Apstein (94), Reighard (94a) and others have maintained the existence of uniformity. Zacharias was inclined to question this (94c, 94d) but has since then changed his views (95c). In the case of recent observers who have noted nonuniformity in distribution

Digitized by Google

(Pitard, 97, Garbini, 98a) and particularly the presence of a greater amount near the shore*, it is probable that proper regard was not paid to depth and that there really exists no considerable difference. Uniformity of horizontal distribution has been shown to be modified by large inflow and by the existence of areas more or less separated from the main body of the lake, by shallows, or in deep bays (Huitfelt-Kaas, Zacharias.)

Regarding vertical distribution, Hofer (95) is alone in placing 35 m., or in one case 65 m., as the lower limit of the plankton. Other observers have noted no such limit and Ward (96b) found plankton even down to 130 m., although he shows that in comparison with the upper portions of the water the deep stratum, 25 m. to the bottom, contains very little plankton.

All investigators agree that the upper strata of the water contain proportionately more plankton than any below. Reighard (94) found at a depth of 5 m. that half the plankton occurred in the upper one and one-half meters of water. Apstein (94) and Ward (96) show that much more is found in the surface 2 m. than in any equal stratum below this. From enumeration of the Crustacea alone, Birge (97a) demonstrates that in water having a total depth of 18 m. during the summer 45 per cent is found in the upper 3 m., 25 to 30 per cent in the 3–6 m. level, 15 to 18 per cent in the 6–9 m. level, leaving only 8 to 12 per cent for the lower half of the water. In the fall and winter, however, the distribution of the Crustacea is nearly uniform.

Francé (94) found in Lake Balaton a regular diurnal migration of at least a part of the plankton, governed by light and storm. Zacharias (95) was unable to find any such movement of the plankton in Lake Plön. It is, however, confirmed for Lake Balaton by Daday (97c) in his investigations on the limnetic Crustacea. Marsh (97) and Birge (95a) are positive that it does not exist in the lakes which they studied. Pitard

* Two observers make directly contrary statements in this respect concerning the same lake (Blanc, 95, and Pitard, 97).

Digitized by Google

(97c, 97d) notes the much greater amount of plankton in the surface stratum at night than can be found during the day when a large amount is first met at 5 m. and the maximum at 10 m. Birge (97a) on the basis of precise enumeration is able to show concerning distribution in the upper meter of water that (1) on calm, sunny days the upper 10 cm. of the lake may be almost devoid of Crustacea, while at a depth of 50 cm. the numbers are considerable and may be very great; (2) the upper meter is populated largely by immature Crustacea; (3) in stormy and cloudy weather the Crustacea approach nearer the surface though the number in the upper 10 cm. is always less than at 50 cm.; (4) at night the young become more evenly distributed in this layer and the adults rise from below the 1 m. level towards the surface. Though this is only necessarily true of the single lake studied, it must be said that the observations far exceed in accuracy of data any others yet published.

The vertical distribution of the plankton as a whole is, however, often quite different from that of the individual species. Data regarding these are given by many investigators, none of whom equal Marsh (97) and Birge (97a) in accuracy and amount of evidence presented.

In studying the seasonal distribution of the plankton Apstein (94) found the existence of a minimum in February in contrast with a summer maximum. Zacharias (96f) shows that the monthly mean remains much the same in different years, and gives (96h) a set of records covering hauls made at a definite point every ten days throughout the year. These give a minimum during the winter, a small maximum in May and another greater in amount in August; both the rise to the maximum and the decline from it are very rapid. Huitfeldt-Kaas finds a single maximum in Norwegian lakes in July-August, and a winter minimum in January-February. The approach to the latter is a gradual one, but the former exhibits a rapid rise and fall within a brief period. Here also Sernow.

For Entomostraca, Scourfield (93) places the maximum in September, while Birge (97a) finds a spring maximum in May, followed by a rapid decline to the early summer depression in

Digitized by Google

June; then a midsummer maximum in July, a late summer minimum in August and an autumn maximum in September or October, followed by a decline to the winter minimum of December to April.

The seasonal distribution of individual organisms has been studied by a host of observers, prominent among whom is Zacharias. In the first report of the Plön station (93) records of certain species are given and others are added in each subsequent volume. Calkins (93a) notes a definite culmination for each organism, no two falling at the same time, though most occur during the summer. The diatoms find a maximum in the spring with low temperature of the water, the Cyanophyceae at the end of the hot season with a high temperature of the water and the algae in general at the time of the fall overturning. Zacharias (95d) and others find a considerable agreement in the periodicity of organisms in successive years, while Birge (97a) looks upon the periodicity as really biennial.

At Plön Zacharias (96h) is able to distinguish a winter and a summer plankton and also for a brief period a fall and spring plankton. In October and November the Copepoda rule so that there is nearly a pure copepod plankton; from March to May the diatoms are almost alone and in enormous numbers. This is related to temperature as Schröder (98a) shows that in colder alpine lakes and in streams the diatoms rule while in ponds and lakes of higher temperature their place is taken by the Schizophyceae. Precise data on the seasonal distribution of different Crustacea are contained in the work of Marsh (97) and Birge (97a) who have traced individual species through long periods.

Lauterborn (98) has made observations of importance on the limnetic Rotatoria—nearly half are eurythermic, or perennial; about the same number are stenothermic of the summer variety and only two stenothermic with preference for the winter temperature. The summer and winter forms are all monocyclic, while the perennial species are dicyclic or polycyclic, i. e. producing males and "winter eggs" two or more times yearly.

Digitized by Google

In dicyclic forms the first sexual period falls in the spring and the second in the fall.

Lundberg and Stingelin (97) discuss seasonal dimorphism among Cladocera and shows that in some instances the succession of species is actually only a succession of broods. Lauterborn (98a) shows great variations among Rotifera at different times of the year.

The extreme change in environment in the case of those lakes which are frozen in winter has attracted the attention of numerous observers to the life of the water at that time. According to the observations of Lauterborn (94) the microfauna under the ice is rich in species and often in individuals; even the limnetic fauna endures through the winter, some species in large numbers. Certain Rotatoria are found in summer only, and some Protozoa in winter only. However, accordingly to Zacharias (94e) in Lake Plön, the Protozoa are the first to disappear, then the Rotatoria, the Crustacea reaching a minimum in February and March. The periodicity of these forms is, he believes, ruled not by temperature but by the surface and depth of the water basin. In Finland also, Levander (94) finds a rich limnetic fauna, consisting of various groups, which persists under the ice of lakes and ponds. Of Cladocera, according to Stingelin (95), most forms persist through the winter though those with ephippia disappear, and many forms manifest a marked seasonal dimorphism which as yet has been worked out in only a few species. The investigations of Birge (97a) show that 7 out of the 11 limnetic species of crustacea in Lake Mendota are perennial and present in considerable numbers in the winter plankton, and these numbers are singularly uniform from January to March with a minimum near the first of this period. The Rotifera and the phyto-plankton are also regularly present in this period and become abundant before the breaking up of the ice. Hartwig (98b, cf. 98a) gives precise data for another lake concerning the occurrence and abundance of numerous winter species. Here also Lampert (96). Sundvik believes that the fish may in some cases pass the

Digitized by Google

winter dormant while frozen in the ice of small ponds which are entirely congealed.

Wesenberg-Lund (96) emphasizes the adaptations to the climatic conditions of freshwater existence, particularly to the ice, which are necessary in organisms coming from the sea. This necessity is most evident for surface forms and is manifested in the formation of winter eggs and winter buds. Land animals must undergo modifications particularly in the organs of respiration to fit them for an aquatic life.

In reference to the littoral fauna as a whole only a few scattered notes are at hand. Various authors have attributed the richness of a lake fauna to the development of the littoral area. Reighard (94a) has expanded the idea to a considerable extent. Others have attributed to the opposite cause the poverty of a lacustrine fauna as Ward (96d) in the case of Pine Lake. In this connection it has been frequently pointed out that the development of the littoral flora is an exceedingly important factor. On the whole, but little attention has been paid to the littoral fauna as a whole although isolated groups of organisms from it have been carefully studied. When the reverse has been true, the results attained are rather striking. Thus Entz (97) and his colleagues in the investigation of Lake Balaton found an exceedingly rich littoral fauna, and some progress was made in the distinction of shore "formations" and the characteristic fauna of each. Thus Francé (97) distinguished as protozoan formations, the peat bogs, the muddy shore with reeds, the bottom mud, the sandy and rocky shore, and the plankton.

The investigation of underground waters has received some attention. In New Zealand, Chilton (94) discovered in subterranean streams many forms also common in surface waters, but all pale and transparent. In all the Crustacea save one, eyes were entirely lacking, and in that one no retinal pigment was present. On the other hand, the antennae and other appendages were noticeably elongated. In the caverns of the Adelsberg, Schmeil (94) noted that the subterranean Entomostraca were colorless or pale in contrast with similar forms from

Digitized by Google

surface waters. In the former eyes were present to be sure, but the pigment was much reduced. According to Garbini (96) subterranean forms present these same differences in color from individuals of the species found at the surface but are further distinguished by diminutive size and weakness. Only two species were found which were characteristically subterranean. Lauterborn (94a) notes that much the same species are present on Heligoland in a dark closed well as in an open light one. The fauna was here very scanty. Here also Lorenzi (98). Packard (94) and Lendenfeld (96) have given summaries of our knowledge regarding cave animals with frequent references both morphological and ecological to the freshwater fauna of such localities. The observations of Garbini (96) were made largely on material from water-pipes. Whipple (98a) has made similar studies in Massachusetts. Here also Viré.

Though numerous experimental researches have been made on the ability of animals to become acclimatized to higher temperatures, there have been few observations on the forms which occur under similar conditions in thermal springs. Both Bruner (95) and Kellicott (97a) record species collected from boiling springs, but without more precise data concerning conditions.

The importance of the plankton as fish food was pointed out by Zacharias (93a) and Fric̆ and Vávra (94) and discussed in detail in connection with the food relations of the water by Reighard (94) and Ward (95). Here also Field (97).

Walter (95) demonstrated by statistics the proportional relation in fish ponds between the amount of plankton and the growth of the young fish. Kochs (92) found that Entomostraca could be enormously multiplied by the use of fertilizers in the water, and Zacharias (97) reports that the fertilization of fish ponds doubles the amount of plankton present. Variations in the fertility of different water basins call for more precise investigation and for the selection of suitable areas for intensive aquaculture as in agriculture. Here also Hofer (96).

Istvanffy (94) shows that the diatoms are an important source of food supply to the young fish, but that the species of

Digitized by Google

diatoms in question are those which grow on the shore plants and only rarely the plankton forms. Strodtmann (97) has undertaken valuable statistical investigations on fish food according to which certain species are clearly plankton eaters while others depend upon littoral forms for food. Here also Walter (96b), Grevé (97), Dröscher (97a). Recently, Brockmeier (98) has observed that in some instances gastropods make direct use of the plankton as food.

The problem of the origin of the freshwater fauna has been attacked from many sides. Of a general character may be noted the discussion of Forel (94) who holds that the littoral fauna has come by immigration from the marsh and river, the limnetic has been brought in by birds largely and the abyssal has been differentiated in the lake itself. The distribution of freshwater animals according to de Guerne (93) is influenced (1) by geographic reasons, (2) by zoologic features of the organism. Even to the weakest a current forms no barrier.

A number of observers have studied brackish water basins and the modifications in transition from marine to freshwater conditions. Levander (94a) found in an inlet of the sea typical marine and brackish water forms together with those of the freshwater in about equal numbers. Field (97) studied a long pond manifesting all degrees of salinity and found the greatest number of forms near the point of mean salinity. The forms, however, were more like the hali- than the limno-plankton. An increase in size of various species on prolonged stay in brackish water indicates one possibility in the production of species. Butschinsky (96) noted the mixed character of the fauna in somewhat similar brackish lakes and its variation with changes in the concentration of the salt. Lemmermann (98) investigated a strand lake which had been dammed and in which the salinity was constantly decreasing. The plankton which was notably rich manifested some irregularities traceable to the variable salt content of the water and certain species were localized at various places.

Digitized by Google

According to Scharff (95) the fauna of Ireland has come by direct extension from Scotland and Wales, with which the connection previously existing broke down during the pleistocene period. Hanitsch (95) holds, however, that among the freshwater sponges three of the six species are American. The importation occurred by means of gemmules borne on floating pieces of wood in the Gulf Stream, or indirectly by migrating birds through Greenland. The failure of these species to spread further is explained on the ground of their inability to compete with native species.

Simroth (96) believes that a secondary adaptation of many land plants and animals has followed upon their remigration into fresh water. Such groups as Hydrachnids show clear evidence of a land life. Fresh water has been furthermore a place of refuge for many ancient forms such as the Ganoids, the Dipnoi and the Branchiopoda. Here also Guppy.

Beddard and Lankester show how tropical animals actually are transported from place to place on aquatic plants. Garbini (95b) has obtained positive evidence of passive transportation of freshwater animals in that ten species representing seven groups were actually collected in transit on mammals, birds, amphibians and aquatic insects, thus evincing the important rôle of these forms in the dispersion of the aquatic fauna. Schewiakoff (93a) rightly regards currents of air and water and actively migrating animals as the efficient means of distribution for protozoa. Their successful introduction depends according to Francé (97) not on meteorological conditions but on hydrological surroundings and on associated plant forms. Kofoid (96b) states briefly the agencies, human and meteorological, important in dispersion.

The insufficiency of our knowledge and the impossibility of drawing reliable conclusions regarding the distribution of freshwater forms from the data at present on record are shown by the statements of Hartwig (98) concerning rare Entomostraca and Jennings (98) on a supposed Asiatic rotifer.

The fauna of island lakes is believed by Richard (98) in the case of the Canary Islands to be introduced in the egg stage by

Digitized by Google

birds and winds. Barrois also notes for the fauna of the Azores that the cosmopolitan European species which are present are characterized by resting stages of some sort, indicating thus passive introduction by birds, water insects and also by man. Such a population must have come gradually to the islands.

The success with which plankton organisms may be transported during some stage in their life history is further evinced by the ease with which some of these organisms can be raised from dried mud, as done by Sars. In this dried condition such forms may remain years without losing power of development under satisfactory conditions of environment. The older experiments on that point have recently been confirmed by Atkinson.

Among other agencies in dispersion must be noted the glacial epoch and Voigt has followed out with great care the effect upon the population of mountain brooks produced by the glacial period and the present gradual supplanting of one species by another.

According to Garbini (94) the limnetic fauna is a passive importation from northern centers of dispersion, and Strodtmann (96) finds its extended uniformity both in Europe and North America evidence of a previous common center in northern polar regions from which the limnetic fauna spread southward. The marine forms in Lake Garda Garbini (94) believes are not a *fauna relicta* but either active migrants from the Adriatic in most part or in a few cases passive transports from the northern ocean.

Of especial interest on this question is the discussion concerning the origin of the Nemertines, a purely marine group with scattered freshwater species. According to Montgomery (95a) these forms are of double origin, (1) direct migrants through rivers to lakes and (2) relict forms in lakes. Their recent origin is shown by variable structural features. Du Plessis (95) would limit the former to rivers and to lakes never occupied by the sea. Garbini (96a) thinks those of Lake

Digitized by Google

Garda certainly not of a relict character but introduced passively from northern freshwater bodies.

The presence of a *fauna relicta* in African lakes has received strong confirmation in the recent investigations of Moore on Lake Tanganyika. This water basin contains a medusa, six quasi-marine gastropods, two prawns, one crab and several protozoa, all marine in character and together constituting what the author calls a halolimnic fauna. These geographically isolated forms can not have made their way up the stream flowing from the lake, in fact only one occurs on that shore where the outlet empties into the sea; they cannot have been carried overland, being deep water forms in part at least; they are not like modern oceanic forms, but are similar to Jurassic types. The common freshwater fauna was marked in geologic deposits of that period, hence it originated previous to these halolimnic forms which are consequently evidence of the contamination of the lake by a deep arm of the sea in what is geologically speaking no very remote period of time.

Günther (94), speaking of the relict forms in Africa, notes that the freshening of the water must have come very gradually since evaporation is so rapid in the tropics. Rizzardi (94) finds in a small crater lake a considerable fauna relicta and concludes that this demonstrates the marine origin of the water basin. In discussing another lake Garbini (93) had previously shown that such a fauna may owe its origin to passive introduction. Hoernes (97) states still more sharply the argument in the case of Lake Baikal; a relict fauna does not necessarily demonstrate the relict character of the water basin. The former may have come, as in Lake Baikal, indirectly from the marine source through other bodies of water, no longer in existence; and the connection was in this case more probably with the Mediterranean than with the northern ocean.

Digitized by Google

PICRO-CARMINE AND ALUM-CARMINE AS COUNTER STAINS.

B. D. MYERS, ITHACA, N. Y.

The following paper embodies the results of experiments with picro-carmine and alum-carmine* as counter stains, as developed incidentally during the year in the histologic laboratory at Cornell University.

The excellence of picro-carmine was first noticed last November, in staining developing bone which had been decalcified. Picro-fuchsin† was being regularly used as a counter stain with hematoxylin. Merely for the experiment picro-carmine was used on one section and left nearly two hours. Much to our surprise and pleasure we found that, instead of our section being ruined, we had secured an excellent differentiation. This was not the first attempt with picro-carmine, but always before the time had been short, from two to fifteen minutes.

The advantage of the stain over picro-fuchsin is noticeable in the superiority of differentiation secured as illustrated in the slides presented at the meeting of Microscopical Society.

The embryonal cartilage cells are better marked by the hematoxylin and picro-carmine, for the alkaline picro-carmine does not fade the hematoxylin as does the acid picro-fuchsin.

It is particularly in the zone of calcifying cartilage that this superior differentiation is noticed. The vertically arranged rows of cartilage cells have lost their horizontal septa, but the

*For literature see Lee's Vade Mecum and the most recent publications on the subject by P. Mayer, Ueber Picro-carmin, Zeitschrift für wissenschaftliche Mikroskopie. Vol. XIV, pt. I, p. 18.

†See Freeborn, Trans. N. Y. Path. Soc., 1893, p. 73. Also Studies from the Dept. of Path. of the College of Physicians and Surgeons, Columbia University, N. Y., 1894-5.

Digitized by Google

vertical septa are pronounced and project into the primary marrow cavity as irregular trabeculae of calcified cartilage. The osteoblasts have enveloped these trabeculae with a covering of true bone and at the same time the cartilaginous trabeculae within are being absorbed and true bone substituted.

This true bone, with the picro-carmine, has taken a red which is brilliant in comparison with picro-fuchsin; and the gradually diminishing and disappearing cartilage which, with picro-fuchsin, has taken a stain not distinguishable from that of the cells of the true bone is, with picro-carmine, beautifully differentiated by a clear pronounced blue, showing the alkalinity of the picro-carmine.

This tendency on the part of picro-carmine to bring out the hematoxylin as a blue, while the acid picro-fuchsin fades it, is very noticeable in the tonsil of dog which was next submitted. In the mucous cells near this gland the nuclei, removed as far as possible from the lumen, are brought out with unequalled clearness. The structure of the blood vessels is also brought out with great distinctness, and the differentiation throughout is very marked.

Quite as striking a contrast between picro-carmine and picro-fuchsin is noticed in a section of the pyloric stomach of a kitten. The stain with picro-carmine is not only more differential, but the unstriped muscle of the stomach and blood vessels is brought out much better by the picro-carmine.

During the summer picro-carmine was tried with good results on sections of the fallopian tube of a mare. It has been used with greatest success on tissues which present a mucous surface, and while these successes have been noted, an equal number of failures were encountered, so no claim is made for picro-carmine as a "pan" stain. It seems particularly unsuited for tissues that stain with difficulty.

Ranvier's picro-carmine was used in most of these experiments, but Bizzozero's was used with equal success. Mayer's recent formula was used in the histological laboratory at Cornell last year with results quite as good as those from Ranvier's.

Digitized by Google

In the summary, then, we find picro-carmine, in the cases noted, gives, with hematoxylin, a more differential stain than picro-fuchsin, and shows the characteristic alkaline reaction with hematoxylin, bringing out the hematoxylin as a beautiful sharp blue, while the acid picro-fuchsin tends to fade it. Two hours is, in general, the best time for picro-carmine. There is no danger of overstaining.

ALUM-CARMINE.

During the summer it was my privilege to prepare some slides of liver of guinea pig to show Anthrax bacilli. The bacilli were readily found, and, at the request of Dr. Moore, pathologist and bacteriologist of the New York State Veterinary College, I attempted to get a contrast stain and finally succeeded with alum-carmine. I had tried picro-carmine without success. In fact I have never been able to secure a good stain with picro-carmine on liver. By experiment I found that one hour and fifty minutes with alum-carmine gave the best results. The crystal-violet with which the bacilli were stained, and which is washed out much or entirely by the alcohols and clearer, must be sufficiently intense to permit of thorough dehydration and clearing and yet leave a distinct stain. One and one-half minutes will suffice if care is taken not to leave longer than is necessary in alcohol.

By this stain the nuclei and the cell body are clearly differentiated and the alum-carmine forms a very good contrast stain with the crystal-violet. The simplicity of the method commends it to us. It is suggested that with methylene blue a still greater contrast may be secured.

Cornell University, Sept. 12, 1898.

ADDENDUM.

Since writing the above my attention has been called to the fact that Stöhr in his text book of Histology (p. 156, Second Ed., translated by Dr. Billstein) directs that developing bone be stained with hematoxylin and then with picro-carmine.

Jan. 17, 1899.

NOTE.—I wish to acknowledge my indebtedness to Dr. Kingsbury for suggestions received during the year, regarding the use of picro-carmine.

Digitized by Google

Digitized by Google

A RAPID STAINING APPARATUS.

C. M. MIX, ITHACA, N. Y.

Methods of staining may be roughly arranged in three classes: staining in toto, staining the sections and carrying them through all the steps necessary previous to mounting them in balsam on the slides, and, finally, performing all the work of staining after the sections have been fastened to the slides.

Fig. 1.

The first method is an excellent one, when small pieces of tissue are used. Large pieces would not be penetrated evenly by the staining agent. This method is very rapid; for the sections can be mounted directly from the knife in Canada balsam after removing the paraffin, or, in case the object is imbedded in collodion, it is only necessary to remove the oil, dehydrate, clear and mount. On account of the difficulties in securing good penetration in the staining fluids, this very efficient method has, we are loath to note, a rather limited application.

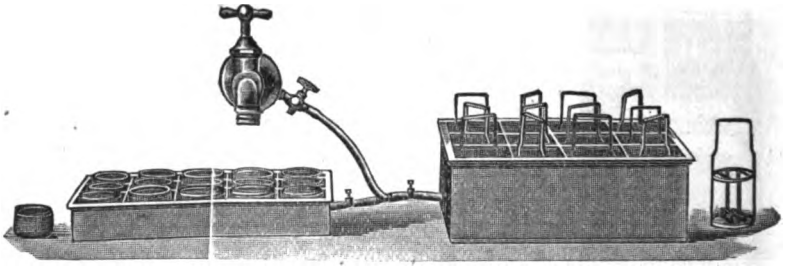
In most cases better results are obtained by staining after the sections are cut. As was suggested above, this result may be obtained in two ways. When pieces of firm, homogeneous tissue, such as pieces of liver, are employed, and in case it is not necessary to preserve the continuity of the series of sections, good results may be obtained by placing the sections as

Digitized by Google

soon as cut in watch glasses, filled with the proper reagents. By transporting them from one dish to another by means of a section lifter, or even by means of a glass rod, the sections may be carried through the various processes necessary to prepare them for mounting, before they are placed upon the slide at all.

This method is entirely inapplicable to serial work, as in embryological investigations for instance. Only firm structures could be treated in this way, for the more delicate ones would rapidly go to pieces, after the removal of the paraffin, without something to hold them in place. Even firm tissues are in great danger of being torn and distorted, or entirely destroyed, by being so often handled. Thus it appears that, for work in which delicate structures are involved, or for pieces of considerable size, both the above methods fail.

To meet these difficulties, the method of staining on the slide



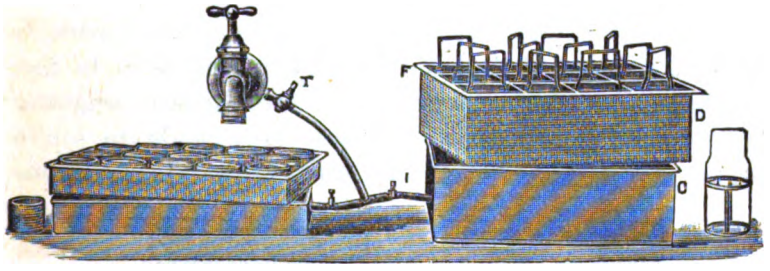
A Fig. 2. B

has been resorted to. As applied in the laboratories of Cornell University, the method is as follows: the sections are fastened to the slide by means of a thin coat of albumen and heat, if imbedded in paraffin, or by a drop of ether-alcohol, if collodion is used. After the removal of the paraffin or oil by means of benzene or xylene, they are treated with ninety-five per cent alcohol. They are now ready to be stained. The slides may now be placed in either the ordinary Stender dish, containing the staining agent, or laid flat on the rack (r, Fig. 5) over the waste jar (w, Fis. 5). In the latter case, the staining agents are poured upon the slides by means of pipettes. Excellent results are uniformly obtained in this way, in serial as well as

Digitized by Google

single sections. Since the section is firmly fastened to the slide, the relative position of the different parts of the tissue is not changed, and the section does not become broken, or lost. If several slides are placed in one of the Stender dishes at the same time, there is always danger of hitting them together and thus destroying the sections. This difficulty becomes particularly annoying in serial sectioning, where, of course, it is of the utmost importance to preserve every section intact.

To hasten the process of staining on the slide and to reduce the danger of injury to the sections, the apparatus described below has been devised. By means of this device, fourteen



A Fig. 3. B

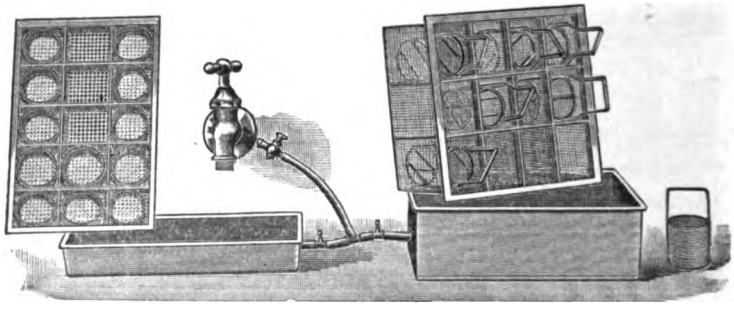
slides can be stained in the time usually required for one, and the danger of injury to the section is entirely obviated. This apparatus was designed and its efficiency thoroughly tested in the laboratories of Cornell University.

The apparatus was designed primarily for work with Heidenhain's iron-hematoxylin, in the use of which, in order to obtain a permanent stain, it is necessary to wash the sections for some time in running water. Hence, with the essential part of the apparatus, there is combined a washer, which will be described later. The principal part of this staining device is a carrier, or slide holder (Fig. 1, b). It consists of two rings cut out of stiff sheet brass. The rings are about one-third of a centimeter in width and about five centimeters in diameter. They are held parallel to each other and about six centimeters apart by four upright standard pieces of the same material.

Digitized by Google

These upright pieces are arranged parallel to each other and at right angles to the rings. Two of them extend about six centimeters above the upper ring to form the handle. In this way we have a skeleton basket. Across the bottom ring extend two parallel pieces of brass, arranged at right angles to the handle. In the upper edge of each of these cross strips are seven notches, opposite each other, and of such a size as to receive, in each pair of notches, the ends of two slides, placed back to back (Fig. 1, a and b). These carriers are five centimeters in diameter and hold fourteen slides. They are made to fit a museum jar of convenient size, described above (Fig. 1, a). Any vessel of convenient size might be used with carrier to match.

This jar for holding the reagents is the No. 2605 made by Whitall, Tatum & Co., New York City. It is listed in their catalogue as museum jar—diameter two inches; height to shoulder, three and three-fourths inches; height to top of stopper, five and one-half inches; width of mouth, two inches.



A Fig. 4. B

The handle of the carrier extends into the hollow stopper when the vessel is closed. These glass stoppers are ground to fit the necks of the bottles, so that the vessels are tightly closed, and in consequence evaporation is prevented.

The third part of this apparatus consists of a washer very similar in construction to and identical in principle with the tissue washer described by Prof. Gage in his article in the July (1898) Journal of Applied Microscopy (Figs.

Digitized by Google

2, 3 and 4, b). The washer consists of two parts—an oblong brass box 24 centimeters long, 19 centimeters wide, and 9 centimeters deep (Fig. 3, c). At one of the lower corners is an inlet tube (i) to which is attached a piece of rubber tubing extending to the tap (t) from which is derived the supply of water. Inside this box (c), which is water tight, is a second box (d), made one centimeter smaller all around, so as to easily fit inside of the first. From the upper edges of this inside box there projects a flange (f) which rests upon the upper edges of the outside box. Thus a water space of about one centimeter is left between the outer and the inner box. The inner box, unlike the outer one, is made of perforated brass and allows the water to pass freely through it. By means of five cross partitions, which intersect at right angles, the perforated box is divided into twelve compartments, each six centimeters square (Fig. 2, c). Each compartment is large enough to hold one of the slide carriers. In this way a constant and gentle current is maintained, and the preparations do not become dislodged from the slides.

Fig. 5.

The slides with the preparations attached are placed in the notches back to back. Then the carrier with its fourteen slides is placed successively in the various reagents contained in the jars described above. When hematoxylin and some counterstain, as picro-fuchsin, are used, six jars are necessary to complete the outfit (Fig. 5).

Digitized by Google

The advantages of this apparatus over the old method are obvious at a glance. The slides are not touched, either with fingers or forceps, from the time they are placed in the carrier until they are removed from the clearer to be mounted. They are held in a stable position, so that it is impossible for the preparations to be injured by hitting against each other or the sides of the jar. By exercising a little care in lifting the carrier from the liquid, only the gentlest of currents is produced. In the hands even of an unskilled operator, the danger of injury to the sections is reduced almost to zero. Fourteen slides can be prepared with the labor incident upon the preparation of one by the old method. When a large number of slides is being prepared, it expedites matters to start a second carrier of slides as soon as the first carrier is removed from the first bottle, and so on until the whole number to be prepared is under way. This applies especially to serial work or the making of large numbers of duplicate slides for classes.

In a word, this apparatus, which, in its simplest form, need consist only of the carrier and the reagent jar, simplifies and makes available for wholesale preparation the best and most accurate method of staining, namely, the method of staining on the slide. It removes all danger of accident to the sections. The danger of distortion is reduced to a minimum. Great rapidity is obtained, and a complicated process is simplified.

Cornell University.

Digitized by Google

PROCEEDINGS

OF

The American Microscopical Society.

MINUTES OF THE ANNUAL MEETING

HELD AT

SYRACUSE, N. Y., AUG. 30, 31 AND SEPT. 1, 1898.

FIRST SESSION.

TUESDAY, August 30, 1898, 10 o'clock A. M.

The meeting was called to order by Dr. A. Clifford Mercer, the acting president. He introduced Prof. Chas. W. Hargitt, who delivered an address of welcome on behalf of the Syracuse Academy of Science. Prof. John Van Duyn was then introduced by Dr. Mercer and welcomed the society on behalf of the Medical College of Syracuse. The acting president responded on behalf of the Society, after which he declared the meeting ready for business.

In the absence of the Secretary, Dr. W. C. Krauss, who was detained by sickness, Magnus Pflaum was appointed acting Secretary.

The Executive Committee recommended the following for membership:

Dr. Mary Amanda Dixon Jones, New York City.
Dr. Henry D. Didema, Syracuse, N. Y.
Dr. F. W. Higgins, Cortland, N. Y.
Mr. Luther B. Elliott, Rochester, N. Y.
Dr. J. W. Mobley, Milledgeville, Ga.
Prof. Chas. Fordyce, University Place, Neb.
Prof. G. E. Condra, Lincoln, Neb.

All of whom were duly elected as members.

Digitized by Google

A biography of the late President, Prof. D. S. Kellicott, prepared by Dr. A. M. Bleile, was read by the Secretary.

Biographies of Professors Wm. A. Rogers and H. C. Coon, prepared by Prof. S. H. Gage, were read by Dr. A. C. Mercer.

The following papers were then presented:

"Special Structural Features in the Air Sacs of Birds." Read by Miss Mary A. Ross, A. B.

A discussion of the paper by Dr. Moore and Prof. Hargitt followed.

The next paper, "A Report of a Student's Work in the Micrometry of the Blood Corpuscles of Individuals of Different Nationalities," was read by Dr. Moses C. White.

Discussion by Dr. Higgins and Magnus Pflaum.

"Teaching of Correct and Definite Method in the Use of the Substage Condenser," a demonstration by Dr. A. C. Mercer, was interesting and instructive.

The President appointed Burton D. Myers and L. B. Elliott as members of the auditing commmittee, after which the meeting adjourned.

SECOND SESSION.

TUESDAY, August 30, 1898, 2 o'clock P. M.

After the meeting was called to order by the President the following papers were presented:

"Method for Preparing Nucleated Blood in Bulk for Class Demonstrations," by Dr. T. B. Oertel, in the absence of the author was read by L. B. Elliott.

"History of the Toad Tadpole's Tail," by B. F. Kingsbury, Ph. D., read by C. M. Mix.

"Use of Picro-carmine and Alum-carmine," by B. D. Myers.

"Rapid Staining and Washing Apparatus," a demonstration by C. M. Mix.

"Photo-Micrography with Opaque Objects," by W. H. Walmsley, read by Dr. A. C. Mercer.

"The Business Management of Laboratories," orally delivered by L. B. Elliott.

Digitized by Google

"Microscopic Examination of Legal Documents," by Dr. Geo. E. Fell, read by title.

"Some Laboratory Apparatus for Histology," by Prof S. H. Gage, read by title.

"An Occurrance of Albino Eggs of the Spotted Salamander, *Amblystoma punctatum*," read by Mr. Horace W. Britcher, of Syracuse, N. Y.

THIRD SESSION.

TUESDAY, August 30, 1898, 8 o'clock P. M.

The meeting was held in the new hall of the University Building. The Acting President, Dr. V. A. Moore, delivered the annual address, after which an informal reception was held on the invitation of the Citizens' Club of Syracuse, at their rooms in the University Building.

FOURTH SESSION.

WEDNESDAY, August 31, 1898, 10 o'clock A. M.

The meeting was called to order by the President.

On the recommendation of the Executive Committee, Mr. Henry R. Howland, A. M., was elected to membership.

The President appointed the following as members of the nominating committee:

Dr. Raymond C. Reed, Dr. A. M. Veeder, Mr. L. B. Elliott, Mr. Herbert R. Spencer and Dr. Geo. E. Clark.

After a short business session the following papers were presented:

"Notices of Some Undescribed Infusoria from the Fauna of Louisiana," by Mr. J. C. Smith, read by title.

"Experiments in Feeding some Insects with Cultures of Comma, or Cholera Bacilli," by Dr. R. L. Maddox; read by title.

"Questions in Regard to the Diphtheria Bacillus," by Dr. A. M. Veeder, delivered orally.

"Means and Methods for Giving Instruction in Bacteriology," by Raymond C. Reed, a demonstration.

Digitized by Google

"The Resistance of Certain Species of Bacteria in the Milk Ducts of Cows," by A. W. Ward, of Ithaca, N. Y., delivered orally from notes.

"What Shall be Taught in a Short Course in Bacteriology," by Dr. Veranus A. Moore, read by title.

"The Comparative Value of the Different Methods of Plankton Measurements," by Prof. Henry B. Ward, read by title.

"Work Done in Lacustrine Biology, 1893-1898," by Prof. Henry B. Ward, read by title.

FIFTH SESSION.

WEDNESDAY, August 31, 1898, 2 o'clock P. M.

The afternoon was given to the inspection of the Medical College, and the members were treated to a demonstration and examination of its various apparatus by the professors of the College.

Dr. Moses C. White gave a demonstration of "The Electric Projection Microscope in Histology with a New Departure in Objectives."

SIXTH SESSION.

WEDNESDAY, August 31, 1898, 8 o'clock P. M.

A Microscopical Soiree was held at the Medical College.

SEVENTH SESSION.

THURSDAY, September 1, 1898, 8 o'clock A. M.

The meeting was called to order by the President and the following papers were presented:

"New Discoveries in Cancer," by Dr. Mary Amanda Dixon Jones, read by Dr. A. C. Mercer.

A paper by Dr. A. A. Young was read by title.

"A New Triple Differential Stain," by Dr. C. W. Kellogg, read by title.

The regular business of the society was then taken up.

The Treasurer reported all debts paid and a balance of $76.48 in the treasury.

Digitized by Google

The Auditing Committee not being present, Dr. A. C. Mercer moved that the Treasurer's Report, if acceptable to the Executive Committee, should be pubished. Carried.

The same motion was made in regard to the Secretary's Report and carried.

The report of the Nominating Committee was as follows:

For President: Dr. Wm. C. Krauss, Buffalo, N. Y.

For Vice Presidents: Dr. A. M. Bleile, Columbus, O.; Dr. G. Carl Huber, Ann Arbor, Mich.

For Secretary: Prof. Henry B. Ward, Lincoln, Neb.

For Treasurer: Magnus Pflaum, Esq.; Pittsburg, Pa.

For elective members of the Executive Committee: Prof. S. H. Gage, Ithaca, N. Y.; Dr. A. Clifford Mercer, Syracuse, N. Y.; Dr. Veranus A. Moore, Ithaca, N. Y.

All of the above officers were duly elected by ballot.

Dr. A. C. Mercer moved that the Society send greetings to Dr. W. C. Krauss with hopes for his speedy recovery. Carried.

A letter read by Dr. A. C. Mercer, from Prof. Hamilton L. Smith, was ordered to be filed.

Mr. Pflaum read a letter from Dr. Geo. C. Taylor which was ordered to be filed and answered.

Mr. Pflaum moved that the thanks of the Society be given to Dr. A. C. Mercer and the local committee. Carried.

Dr. A. C. Mercer moved that "The General Organization of the Society be referred to the Executive Committee for consideration in all directions and details, and that it report at the next meeting of the Society." Carried.

Dr. A. M. Veeder moved that a vote of thanks be given to the press of Syracuse for its reports of the meeting. Carried.

Prof. Raymond C. Reed moved that a vote of thanks be given to the Syracuse Academy of Science and the faculty and officers of the University of Syracuse. Carried.

Dr. A. C. Mercer moved that a vote of thanks be given to the acting President and Secretary. Carried.

Mr. L. B. Elliott moved that the Secretary notify all officers of their election, to give them detail of action taken at this

Digitized by Google

meeting and request their activity for the next meeting. Carried.

Dr. A. C. Mercer moved that Prof. S. H. Gage be requested to send to the family of Prof. D. S. Kellicott, deceased, our late President, an expression of sympathy on the part of the Society. Carried.

Adjournment sine die.

In the afternoon the members were treated to a carriage ride with a visit to the Syracuse Water Works and to the New York State Institution for Feeble Minded Children. The former was fully shown and explained by its Superintendent, Mr. Wm. R. Hill, the latter by Superintendent Dr. James C. Carson. The drive and especially its purpose were thoroughly enjoyed by the participants.

An interesting feature of the meeting, greatly appreciated by the members and visitors, was the exhibit of the latest production of Microscopes and Acccessories, furnished by the Bausch & Lomb Optical Company, the Spencer Lens Company and Richards & Co. Also the exhibit of X Ray Apparatus by the Edison Manufacturing Co. received its full share of attention.

Thus ended successfully a meeting which, by reason of unexpected occurrences, seemed, until the last moment, most discouraging of results. The President, Prof. D. S. Kellicott, who suggested Syracuse and on whose account it was chosen as the meeting place, and who undertook the preparations for the meeting, had died. The Secretary, Dr. W. C. Krauss, became sick, and during a time when his services were most needed to ensure a good meeting, was near death's door. The whole burden of arranging the meeting was suddenly thrown on the shoulders of Dr. A. C. Mercer in charge of the local committee and Dr. Veranus A. Moore, who became acting President. The Society cannot sufficiently appreciate their services.

MAGNUS PFLAUM,
Acting Secretary.

Digitized by Google

TREASURER'S REPORT

FOR THE YEAR ENDING AUGUST 17, 1898.

DR.

To balance on hand Toledo Meeting.....		$ 16.61
To Membership dues, 1897, 8.....	$ 16.00	
To Membership dues, 1898, 194.....	388.00	
To Membership dues, 1899, 2.....	4.00	
		408.00
To Admission fees, 1898, 11.....		33.00
To donation by Author for plates.....		13.50
To Subscribers.....		34.00
To sale of Proceedings.....		101.00
To Advertising, 1897.....	7.00	
To Advertising, 1898.....	75.00	
		82.00
To Postage and Expressage collected.....		.95
		$ 693.06

CR.

By Expense Toledo Meeting.....	3.60	
By Postage.....	31.58	
By Expressage.....	31.02	
By Stationary and Printing.....	12.90	
By Sundries.....	13.93	
By issuing Vol. XVIII, balance.....	149.90	
By issuing Vol. XIX, printing..... 259.95		
" " " " plates..... 73.75		
	333.70	
By investment Spencer-Tolles Fund.....	40.00	
		616.58
By balance on hand.....		76.48
		$ 693.06

Digitized by Google

SPENCER-TOLLES FUND.

Amount reported at Toledo Meeting	$ 496.03
Subscriptions	4.00
Dividends January 1, 1898	22.65
Dividends July 1, 1898	23.78
Cash from sale of Proceedings	36.00
Total	$ 555.46
Increase during the year	$86.43

SYRACUSE, N. Y., Sept. 1, 1898.

We hereby certify that we have examined the foregoing accounts for the year 1897-98 and find the same correct, with proper vouchers for expenditures.

SIGNED: BURTON D. MYERS,
L. B. ELLIOTT,
Auditing Committee.

Digitized by Google

CONSTITUTION.

Article I.

This Association shall be called the American Microscopical Society. Its object shall be the encouragement of microscopical research.

Article II.

Any person interested in microscopical science may become a member of this Society upon written application and recommendation by two members and election by the Executive Committee. Honorary members may also be elected by the Society on nomination by the Executive Committee.

Article III.

The officers of this Society shall consist of a President and two Vice-Presidents, who shall hold their office for one year, and shall be ineligible for re-election for two years after the expiration of their terms of office, together with a Secretary and Treasurer, who shall be elected for three years and be eligible for re-election.

Article IV.

The duties of the officers shall be the same as are usual in similar organizations; in addition to which it shall be the duty of the President to deliver an address during the meeting at which he presides; of the Treasurer to act as custodian of the property of the Society, and of the Secretary to edit and publish the Proceedings of the Society.

Article V.

There shall be an Executive Committee, consisting of the officers of the Society, three members elected by the Society, and the past Presidents of the Society and of the American Society of Microscopists.

Digitized by Google

ARTICLE VI.

It shall be the duty of the Executive Committee to fix the time and place of meeting and manage the general affairs of the Society.

ARTICLE VII.

The initiation fee shall be $3.00, and the dues shall be $2.00 annually, payable in advance.

ARTICLE VIII.

The election of officers shall be by ballot.

ARTICLE IX.

Amendments to the Constitution may be made by a two-thirds vote of all members present at any annual meeting, after having been proposed at the preceding annual meeting.

BY-LAWS.

I.

The Executive Committee shall, before the close of the annual meeting for which they are elected, examine the papers presented and decide upon their publication or otherwise dispose of them.

All papers accepted for publication must be completed by the authors and placed in the hands of the Secretary by October 1st succeeding the meeting.

II.

The Secretary shall edit and publish the papers accepted with the necessary illustrations.

III.

The number of copies of Proceedings of any meeting shall be decided at that meeting.

Digitized by Google

IV.

No applicant shall be considered a member until he has paid his dues. Any member failing to pay his dues for two consecutive years, and after two written notifications from the Treasurer, shall be dropped from the roll, with the privilege of reinstatement at any time on payment of all arrears. The Proceedings shall not be sent to any member whose dues are unpaid.

V.

The election of officers shall be held on the morning of the last day of the annual meeting. Their term of office shall commence at the close of the meeting at which they are elected, and shall continue until their successors are elected and qualified.

VI.

Candidates for office shall be nominated by a committee of five members of the Society. This committee shall be elected by a plurality vote, by ballot, after free nomination, on the second day of the annual meeting.

VII.

All motions or resolutions relating to the business of the Society shall be referred for consideration to the Executive Committee before discussion and final action by the Society.

VIII.

Members of the Society shall have the privilege of enrolling members of their families (except men over twenty-one years of age) for any meeting upon payment of one-half the annual subscription ($1.00).

Approved by the Society, August 11, 1892.

Digitized by Google

LIST OF MEMBERS

The figures denote the year of the member's election, except '78, which marks an original member. The TRANSACTIONS are not sent to members in arrears, and two years' arrearage forfeits membership. (See Article IV. of By-Laws.)

Members Elected During the Year 1898.

For addresses see regular list.

BESSEY, CHARLES E., Ph. D., LL. D.
CLEMENTS, FRED. E., A. M. Ph. D.
DAVIS, CHAS. H.
DIDAMA, HENRY D., M. D.
ELLIOTT, LUTHER B.
FINDER, WM., Jr., M. D.
GOODRICH, W. H., M. D.
HIGGINS, F. W., M. D.
HOLMES, A. M., M. D.
HOWLAND, HENRY R., M. D.
JOHNSON, WM. D., M. D.
JONES, MARY A. D., M. D.
MOBLEY, J. W., M. D.
MURPHEY, EUGENE E., M. D.
POUND, ROSCOE, A. M., Ph. D.
WOLCOTT, ROBERT H., A. M., M. D.

ABERDEIN, ROBERT, M. D., F. R. M. S., '82..327 James St., Syracuse, N. Y.
ACKER, GEO. N., M. D., '91..913 Sixteenth St., N. W., Washington, D. C.
AINSLIE, CHARLES N., '92, ...Rochester, Minn.
ALLEGER, WALTER W., M. D., '94,..906 S. St., N. W., Washington, D. C.
ATWOOD, E. S., '79,.....261 W. 34th St. N. Y.
ATWOOD, H. F., F. R. M. S., '78,.... .....Rochester, N. Y.
AYERS, MORGAN W., M. D., '87, ...Upper Montclair, N. J.

BARKER, ALBERT S., '97,..... ....24th and Locust Sts., Philadelphia, Pa.
BARNSFATHER, JAMES, M. D., '91,
Cor. Sixth Ave. and Walnut St., Dayton, Ky.
BARTLETT, CHARLES JOSEPH, M. D., '96,..... .....New Haven, Conn.
BAUSCH, EDWARD, '78, ...179 N. St. Paul St., Rochester, N. Y.
BAUSCH, HENRY, '86,..... .....Rochester, N. Y.
BAUSCH, WILLIAM, '88,.....Rochester, N. Y,
BEAL, Prof. JAMES HARTLEY, '96, ...Scio College, Scio, Ohio
BEARDSLEY, Prof. A. E., '97,.....Greeley, Col.
BELL, CLARK, ESQ., '92,..... 39 Broadway, New York City
BENNETT, HENRY C., '93,.....256 W. 42d St., New York City
BESSEY, Prof. CHARLES EDWIN, Ph. D., LL. D., '98, ... Lincoln, Neb.
BISCOE, Prof. THOMAS D., '91,.....404 Front St., Marietta, Ohio

Digitized by Google

BLEILE, A. M., M. D., '81,.....Ohio State University, Columbus, Ohio
BODINE, Prof. DONALDSON, '96,.....Crawfordsville, Ind.
BOOTH, MARY A., F. R. M. S., '82,.....32 Byers St., Springfield, Mass.
BOYCE, JAMES C., Esq., '86,.....Carnegie Building, Pittsburg, Pa.
BOYCE, JOHN W., M. D., '96,.....23 Mawhinney St., Pittsburg, Pa.
BOYER, C. S., A. M., '92,.....3223 Clifford St., Philadelphia, Pa.
BREDIN, GEO. S., '96,..... ..302 Spitzer Building, Toledo, O.
BROMLEY, ROBERT INNIS, M. D.. '93,.....Sonora, Cal.
BROWN, MISS L. S., '92, ... W. Main St., Angelica, N. Y.
BROWN, N. HOWLAND, '91, ...33 S. 10th St., Philadelphia, Pa.
BROWN, ROBERT, '85, ...Observatory Place, New Haven, Conn.
BRUNDAGE, A. H., M. D., '94, ...1153 Gates Ave., Brooklyn, N. Y.
BULL, JAMES EDGAR, Esq., '92,.....253 Broadway, New York City, N. Y.
BURNER, NATHAN L., M. D., '96,... .368 Hamilton Ave., Columbus, Ohio
BURRILL, Prof. T. J., Ph. D., F. R. M. S., '78.....Urbana, Ill.
BURT, Prof. EDWARD A., '91,.....Middlebury College, Middlebury, Vt.
BUSH, BERTHA E., M. D., '95.....808 Morse Ave., Rogers Park, Ill.

CAMPBELL, D. P., M. D., '88, .Tomichi, White Pine P. O., Gunnison Co., Col.
CARTER, JOHN E., '86,.....Germantown, Philadelphia, Pa.
CHESTER, ALBERT H., A. M., '88,..Rutgers College, New Brunswick, N. J.
CLAPP, GEO. H., '86,..... 116 Water St., Pittsburg. Pa.
CLARK, GAYLORD P., M. D., '96,.....Syracuse, N. Y.
CLARK, GEORGE EDW., M. D., '96.....Skaneateles, Onondaga Co., N. Y.
CLAYPOLE, AGNES M., '94, ...Cornell University, Ithaca, N. Y.
CLAYPOLE, EDITH JANE, Ph. B., M. S., '93,
Wellesley College, Wellesley, Mass.
CLAYPOLE, EDWARD W., B. Sc., F. G. S., '86,. .....Akron, Ohio
CLEMENTS, FREDERICK E., A. M., Ph. D., '98,.....Lincoln, Neb.
COBB, CHAS. N., A. M., '86, ...26 N. Pine St., Albany, N. Y.
COOPE, A. F., M. D., '86,..... 114 Sycamore St., Oil City, Pa.
COUCH, FRANCIS G., '86,
Kalish Pharmacy, 23d St. and 4th Ave., New York City
COX, CHAS. F., F. R. M. S., '85.....Grand Central Depot. New York City
CRAIG, THOMAS, '93,.....244 Greenpoint Ave., Brooklyn, N. Y.
CUNNINGHAM, M. C., '96,..... Board of Health, Pittsburg, Pa.

DAVIS, CHAS. H., '98.....Drawer 1033, Rochester, N. Y.
DAVIS, W. Z., '86,.....Marion, Ohio
DEAN, N. B. H., M. D., '96, ...Young St., Brighton, Ont.
DIDAMA, HENRY D., M. D., '98,.....424 S. Salina St., Syracuse, N. Y.
DIEHL, ALFRED C., M. D., '96, ...361 Pearl St., Buffalo, N. Y.
DORR, L. BRADLEY, A. B., M. D., '96....300 Jefferson St., Buffalo, N. Y.
DORR, S. HOBART, Ph. G., '95,.....945 Niagara St., Buffalo, N. Y.
DORT, MISS ELIZABETH, '96,.....608 Filmore Ave., Buffalo, N. Y.
DOUBLEDAY, HENRY H., Esq., '90,..715 H. St., N. W., Washington, D. C.
DRESCHER, W. E., '87, ...Box 1033, Rochester, N. Y.
DUNHAM, E. K., M. D., '92,.....338 E. 26th St., New York City

Digitized by Google

EASTMAN, LEWIS M., M. D., F. R. M. S., '82,
772 W. Lexington St., Baltimore, Md.
EIGENMANN, Prof. C. H., '95,...University of Indiana, Bloomington, Ind.
ELLIOTT, Prof. ARTHUR H., '91,.....4 Irving Place, New York City
ELLIOTT, LUTHER B., '98,.....4 Fulton Ave., Rochester, N. Y.
ELSNER, JOHN, M. D.. '88,.....P. O. Box 454, Denver, Col.
ELWELL, A. T., '89,..... .....16 Pearl St., Council Bluffs, Iowa
EWELL, MARSHALL D., LL. D., M. D., F. R. M. S., '85,
618 and 619 Ashland Block, Chicago, Ill.

FEIEL, ADOLPH, M. D., '81,.....520 E. Main St., Columbus, Ohio
FELL, GEO. E., M. D., F. R. M. S., '78,.....72 Niagara St., Buffalo, N. Y.
FELLOWS, CHAS. S., F. R. M. S., '88,
28 Chamber Commerce, Milwaukee, Wis.
FERRIS, Prof. HARRY B., '96,..... 118 York St., New Haven, Conn.
FIELD, A. G., M. D., '82,.....Summit Place, Des Moines, Iowa
FINDER, WM., Jr., M. D., '98,.....2 Union Place, Troy, N. Y.
FISHER, MAX, '93,.....Zeiss Optical Works, Jena, Germany
FLINT, JAMES M., M. D., '91,.....''The Portland,'' Washington, D. C.
FORDYCE, CHARLES, B. S., A. M., '98,
Nebraska Wesleyan University, University Place, Neb.
FOX, OSCAR C., '92,.....U. S. Patent Office, Washington, D. C.
FULLER, CHAS. G., M. D., F. R. M. S., '81,
39 Central Music Hall, Chicago, Ill.

GAERTNER, FRED, M. D., '87,.....3519 Penn. Ave., Pittsburg, Pa.
GAGE, Prof. SIMON H., B. S., '82,.....Cornell University, Ithaca, N. Y.
GAGE, MRS. SUSANNA PHELPS, '87,.....Ithaca, N. Y.
GATES, ELMER, '96,..... .....Chevy Chase, Md.
GOODRICH, W. H., M. D., '98,..... ....Augusta, Ga.
GREEN, MISS ISABELLA M., M. S., '96,...St. Mary's School, Raleigh, N. C.

HAAG, D. E., M. D., F. R. M. S., '86,.. 1121 Washington St., Toledo, Ohio
HANAMAN, C. E., F. R. M. S., '79,... .....Box 527, Troy, N. Y.
HANKS, HENRY G., '86, ...718 Montgomery St., San Francisco, Cal.
HASENCAMP, OSCAR, M. D.,.....Cor. Cherry and Ontario Sts., Toledo, O.
HATFIELD, JOHN J. B., '82,.....333 Arsenal Ave., Indianapolis, Ind.
HEALD, GEORGE HENRY, M. D., '96,.....Battle Creek, Mich.
HEINEMAN, H. NEWTON, M. D., '91,..... 60 W. Fifty-sixth St., New York
HERTZLER, ARTHUR A., M. D., '96,.....Halstead, Kan.
HIGGINS, F. W., M. D., '98,.....Courtland, N. Y.
HILL, HERBERT M., Ph. D., '87,.....24 High St., Buffalo, N. Y.
HOFFMAN, JOS. H., M. D., '96,.....111 Steuben St., Pittsburg, Pa.
HOLBROOK, M. L., M. D., '82,..... 46 E. Twenty-first St., New York
HOLMES, A. M., M. D.. '98,.....Jackson Block, Denver, Colo.
HOSKINS, WM., '79.....Room 55, 81 S. Clark St., Chicago, Ill.
HOWARD, CURTIS C., M. D., '88,..Starling Medical College, Columbus, O.
HOWE, LUCIEN, M. D., F. R. M. S., '78,..87 W. Huron St., Buffalo, N. Y.

Digitized by Google

HOWLAND, HENRY R., A. M., '98,.....217 Sumner St., Buffalo, N Y.
HUBER, G. CARL, M. D., F. R. M. S., '90, 24 E. Ann St., Ann Arbor, Mich.
HUMPHREY, O. D., Ph. D., '95,..... .....Jamaica, N. Y.
HYATT, J. D., '78,.....69 Burling Lane, New Rochelle, N. Y.

JACKSON, CHEVALIER Q., M. D., '87,.....63 Sixth Ave., Pittsburg, Pa.
JAMES, BUSHROD W., M. D., '94,
N. E. cor. Green and Eighteenth Sts., Philadelphia, Pa.
JAMES, FRANK L., Ph. D., M. D., '82,.....Box 568, St. Louis, Mo.
JAMES, GEO. W., '92,.....108 Lake St., Chicago, Ill.
JOHNSON, FRANK S., M. D., '83,.....2521 Prairie Ave., Chicago, Ill.
JOHNSON, WM. D., M. D. '98,..... ....Bergen, N. Y.
JOHNSTON, LEVI D., M. D,, '96,..... .....Whittier, Cal.
JONES, Mrs. MARY A. DIXON, M. D., '98,. 439 W. 162 St., New York City.

KELLOGG, J. H., M. D., '78,... .....Battle Creek, Mich.
KERR, ABRAM TUCKER, JR., '95,.....1386 Main St., Buffalo, N. Y.
KINGSBURY, BENJ. F., A. B., M. S., '94,.....Ithaca, N. Y.
KIRKPATRICK, T. J., '88,..... .....Springfield, Ohio.
KLINE, A. T., '97,.....335 Superior St., Toledo, Ohio.
KOTZ, A. L., M. D., '91 .....58 S. Fourth St., Easton, Pa.
KRAFFT, WILLIAM, '95,..... .....411 W. 59th St., New York.
KRAUSS, WM. C., B. S., M. D., F. R. M. S., '90,
371 Delaware Ave., Buffalo, N. Y.
KUHNE, F. W., '79,.....19 Court St., Fort Wayne, Ind.

LAMB, J. MELVIN, M. D., '91,.....906 G St., N. W., Washington, D. C.
LANDSBERG, A., '79,.....156 Woodward Ave., Detroit, Mich.
LATHAM, MISS V., D. D. S., F. R. M. S., '88, 808 Morse Ave., Chicago, Ill.
LAWTON, EDWARD P., '88,.....3 Linden Ave., Troy, N. Y.
LEIPPE, J. HARRY, '96,... .....2nd and Franklin Sts., Reading, Pa.
LEWIS, MRS. KATHARINE B., '89, "Elmstone," 656 7th St., Buffalo, N. Y.
LEWIS, IRA W., '87,.....Dixon, Ill.
LINE, J. EDWARD, D. D. S., F. R. M. S., '82, 39 State St., Rochester, N. Y.
LOCKE, JOHN D., 98,.... .....4 Lafayette Sq., Washington, D. C.
LOMB, ADOLPH, '92,.....48 Clinton Place, Rochester, N. Y.
LOMB, HENRY, '84,.....48 Clinton Place, Rochester, N. Y.
LOOMIS, CHANDLER H., '97, Atlantic Dredging Co., 31 Pine St. N. Y. City.
LOVE, Prof. E. G., '91,.....80 E. 55th St., New York City.
LOVELAND, A. E., M. A., M. D.,'97,....McLean Hospital, Waverly, Mass.
LYON, HOWARD N., M. D., '84,.....39 Belleview Place, Chicago, Ill.

MANTON, W. P., M. D., F. R. M. S., '85, 82 W. Adams Ave., Detroit, Mich.
MARSHALL, COLLINS, M. D., '96,.....2507 Penn Ave., Washington, D. C.
MARSHALL, WM., JR., '92,.....Coudersport, Pa.
MASTERMAN, ELMER E., '97,.....New London, Ohio.
MCCALLA, ALBERT, Ph. D., '80,
414 Monadnock, Dearborn and Jackson Sts., Chicago, Ill.

Digitized by Google

McKay, Joseph, '84,.....259 Eighth St., Troy, N. Y.
McKim, Rev. Haslett, '85,.....83 W. Twentieth St., New York City.
Meader, Lee Douglass, M. D., '96, 914 E. McMillen St., Cincinnati, O.
Mellor, Chas. C., '85,.....77 Fifth Ave., Pittsburg, Pa.
Mercer, A. Clifford, M. D., F. R. M. S., '82,
324 Montgomery St., Syracuse, N. Y.
Mercer, Frederick W., M. D., F. R. M. S., '83,
2540 Prairie Ave., Chicago, Ill.
Miller, John A., Ph. D., F. R. M. S., '89, 255 Ellicott St., Buffalo, N. Y.
Milnor, Chas. G., '86,.....318 Highland Ave., Pittsburg, Pa.
Mobley, J. W., M. D., '98,.....Milledgeville, Ga.
Moody, Robert O., M. D., '91 ,.....1204 Chapel St., New Haven, Conn.
Moore, Prof. V. A., M. D., '87,.....Cornell University, Ithaca, N. Y.
Murphy, Eugene E., M. D., '98,..... .Augusta, Ga.
Myers, Burton D., '97,.....89 N. Tioga St., Ithaca, N. Y.

Nunn, Richard J., M. D., '83,.....119½ York St., Savannah, Ga.

Oertel, T. E., M. D., '92,.....Med. Dept., Univ. of Ga., Augusta, Ga.
Ohler, W. H., '91,..... .....18 Locust St., Portland, Me.
Olin, R. C., M. D., '90,..... ....32 Adams Ave. West, Detroit, Mich.
Olsen, Alfred Berthier, M. D., '96,
Med. Miss. Training School, 1926 Wabash Ave., Chicago, Ill.

Paquin, Paul, M. D., '91, ...3536 Olive St., St. Louis, Mo.
Park, Roswell, A. M., M. D., '84,....510 Delaware Ave., Buffalo, N. Y.
Patrick, Frank, Ph. D., '91,.....601 Kansas Ave., Topeka, Kan.
Pease, Fred. N., '87.....Box 210, Altoona, Pa.
Pennock, Ed., '79,..... 3609 Woodland Ave., Philadelphia, Pa.
Perry, Stuart H., Esq., '90,
Cor. Saginaw and Lawrence Sts., Pontiac, Mich.
Pflaum, Magnus, Esq., '91,..... 415 Grant St., Pittsburg, Pa.
Piwonka, F., Esq., '97,.....243 Superior St., Cleveland, Ohio.
Pound, Roscoe, A. M., Ph. D., '98,.....Lincoln, Neb.
Pyburn, George, M. D., '86,.....1011 H St., Sacramento, Cal.

Reed, Raymond C., '97,.....108 University Ave., Ithaca, N. Y.
Reyburn, Robert, M. D., '90,.....2129 F St., N. W., Washington, D. C.
Reynolds, William George, M. D., '97,.....Woodbury, Conn.
Rice, Francis Scott, '96, Cor. Third St. and Eastern Ave., Aspinwall, Pa.
Robbins, Henry A., M. D., '91,....1750 M St., N. W., Washington, D. C.

Sampson, Allen W., M. D., '96,..... ....Penn Yan, N. Y.
Schmitz, Henry, M. D., '96,.....518 W. Chicago Ave., Chicago, Ill.
Schwerdtfeger, Louis Charles, Esq., '96,....Lincoln, Logan Co,, Ill.
Seaman, Wm. H., M. D., '86, 1424 Eleventh St., N. W., Washington, D. C.
Secor, Jabin A., '95,.....Elmira, N. Y.
Seymour, Prof. M. L., '85,.....Chico, Cal.

Digitized by Google

SHEARER, J. B., '88..... 809 Adams St., Bay City, Mich.
SHULTZ, CHAS. S., '82,..... .....Hoboken, N. J.
SIEMON, RUDOLPH, '91.....22 E. Jefferson St., Fort Wayne, Ind.
SLOCUM, CHAS, E., Ph. D., M. D., '78,.....Defiance, Ohio.
SMITH, J. C., '96,.....131 Carondelet St., New Orleans, La.
SNYDER, JAMES B., D. D. S., '97, ...Bryan, Ohio.
SPENCER, HERBERT R., '85,.....367 Seventh St., Buffalo, N. Y.
STILLSON, J. O., A. M., M. D., '80,...445 N. Penna St., Indianapolis, Ind.
STOCKWELL, RODNEY R., '96, ...Box 509, New Brighton, Pa.
STONEY, ROBERT J., Jr., '96, ...P. O. Box 363, Pittsburg, Pa.
STOWELL, THOMAS B., A. M., Ph. D., '82,
State Normal School, Potsdam, N. Y.
SUMMERS, Prof. H. E., '86,.....University of Illinois, Champaign, Ill.

THOMAS, Prof. MASON B., '90,.... Wabash College, Crawfordsville, Ind.
THORNBURY, FRANK J., M. D., '96.....401 Delaware Ave., Buffalo, N. Y.
TIMMINS, GEORGE, '96,.....Syracuse, N. Y.
TWINING, FREDERICK E., '96.....1833 Mariposa St., Fresno, Cal.

VANDERPOEL, FRANK, M. E., '87,.....191 Roseville Ave., Newark, N. J.
VEEDER, ANDREW T., M. D., '83,
Horne Office Building, Penn Ave., Pittsburg, Pa.
VEEDER, M. A., M. D., '85,.....Lock Box 1108, Lyons, N. Y.
VORCE, C. M., ESQ., F. R. M. S., '78,.....5 Rouse Block, Cleveland, Ohio.
VREDENBURGH, E. H., '84,.....122 S. Fitzhugh St., Rochester, N. Y.

WALMSLEY, W. H., F. R. M. S., '78,.....4248 Pine St., Philadelphia, Pa.
WARD, Prof. HENRY B., A. M., Ph. D., '87,
University of Nebraska, Lincoln, Neb.
WEBER, Prof. HENRY A., Ph. D., '86,....1342 Forsyth Ave., Columbus, O.
WEIGHTMAN, CHAS. H., '86,.....5859 Michigan Ave., Chicago, Ill.
WELCH, GEO. O., M. D., '91,.....Box 416, Fergus Falls, Minn.
WENDE, ERNEST, M. D., '91,..... 471 Delaware Ave., Buffalo, N. Y.
WERUM, J. H., '93,..... 508 Adams St., Toledo, Ohio
WHELPLEY, H. M., M. D., Ph. G., F. R. M. S., '90,
2342 Albion Place, St. Louis, Mo.
WHITE, JONATHAN, ESQ., '91,..... 14 Maple Ave., Brockton, Mass.
WHITE, MOSES, C., M. D., '85,.....Box 1674, New Haven, Conn.
WHITLEY, JAMES D., M. D., '85,.....Petersburg, Ill.
WIARD, MARTIN S., '86,.....21 Walnut St., New Britain, Conn.
WILLSON, LEONIDAS A., ESQ., '85,.... 112 Public Square, Cleveland, Ohio
WILSON, Mrs. MARY R., M. D., '95,.....Ithaca, N. Y.
WOLCOTT, ROBERT HENRY, A. M., M. D., '98,.....Lincoln, Neb.
WOODWARD, ANTHONY, '85,..... 206 W. 128th St., New York City
WOODWARD, A. L., '97,.....93 Park Ave., Utica, N. Y.

YOUNG, AUGUSTUS A., M. D., '92,
22 E. Miller St., Newark, Wayne Co., N. Y.
YZNAGA, JOSÉ M., ESQ., '90,.....612 F St., N. W., Washington, D. C.
ZENTMAYER, FRANK, '91,.....209 S. Eleventh St., Philadelphia, Pa.

Digitized by Google

HONORARY MEMBERS

COX, JACOB D., LL. D., F. R. M. S.,.....Oberlin, Ohio
CRISP, FRANK, LL. B., B. A., F. R. M. S.,
5 Landsdowne Road, Nottingham Hill, London, England
DALLINGER, Rev. W. H., F. R. S., F. R. M. S.,
Ingleside, Lee, S. E., London, England
HUDSON, Rev. C. T., A. M., LL. D., F. R. M. S.,
6 Royal York Crescent, Clifton, Bristol, England
MADDOX, R. L., M. D., Hon. F. R. M. S.,
Greenbank, 45 Park Road, Portswood, Southampton, England
SMITH, HAMILTON L., LL. D., F. R. M. S.,.....Geneva, N. Y.
WARD, R. H., M. A., M. D., F. R. M. S., ... 53 Fourth St., Troy, N. Y.

SUBSCRIBERS

PUBLIC LIBRARY,.....Detroit, Mich., one copy
FIELD COLUMBIAN MUSEUM,.....Chicago, Ill., one copy
COLUMBIA UNIVERSITY LIBRARY, ...New York City, one copy
NEW YORK PUBLIC LIBRARY,..... .....New York City, one copy
DULAU & CO.,.....37 Soho Square, London, England, two copies
CARNEGIE LIBRARY,.....Pittsburg, Pa., one copy
SYRACUSE CENTRAL LIBRARY,..... .....Syracuse, N. Y., one copy
ACADEMY OF NATURAL SCIENCES,
Logan Square, Philadelphia, Pa., one copy
NEW YORK ACADEMY OF MEDICINE, 17 W. 43d St., New York City, one copy
THE MISSOURI BOTANICAL GARDEN,..... St. Louis, Mo., one copy
SCIENTIFIC LIBRARY,..U. S. Patent Office, Washington, D. C , one copy
N. Y. STATE VETERINARY COLLEGE,
Cornell University, Ithaca, N. Y., one copy
U. S. MEDICAL MUSEUM AND LIBRARY,
Surgeon General's Office, Washington, D. C., one copy
R. FRIEDLAENDER & SOHN, Berlin, N. W., Carlstr. 11, Germany, one copy
NEW YORK STATE LIBRARY, ...Serial Section, Albany, N. Y., one copy
BOSTON SOCIETY OF NATURAL HISTORY,
Berkeley St., Boston, Mass., one copy
DR. JOS. H. LINSLEY,
Director of Hygienic Laboratory, Burlington, Vt., one copy
LIBRARY OF THE OHIO STATE UNIVERSITY,.....Columbus, O., one copy
LABORATORY OF HISTOLOGY AND EMBRYOLOGY.
University of Minnesota, Minneapolis, Minn., one copy
LIBRARY OF THE UNIVERSITY OF NEBRASKA, ...Lincoln, Neb., one copy

Digitized by Google

BIENNIAL INDEX

FOR VOLUMES XIX AND XX.

Agar-Agar, W. W. Alleger..... 91
Air-sacs of Birds, Special Structural Features in the, Mary J. Ross .. 29
Albino Eggs of the Spotted Salamander, An Occurrence of, Horace W. Britcher..... 69
Alleger, W. W., Agar-Agar..... 91
*Ameba villosa Leidy, The Sporular Development of, J. C. Smith... 69
Annual Address of the Presiding Officer, The Natural in Disease, Veranus A. Moore..... 8
*Arthropods, Some Points on Cleavage Among, Agnes M. Claypole.. 74
Atax, On the North American Species of the Genus, Robert H. Wolcott..... 193

*Bacteria, Dahlia as a Stain For, in Sections Cut by the Collodion Method, Raymond C. Reed..... 182
Bacteria, The Persistence of, in the Milk Ducts of the Cow's Udder, Archibald R. Ward..... 57
*Berry, John M., A Comparison of the Phagocytic Action of Leukocytes in Amphibia and Mammalia..... 98
Birds, Special Structural Features in the Air-sacs of, Mary A. Ross.. 29
Bleile, A. M., Obituary of David Simons Kellicott..... 21
Blood Counts, Effect of High Altitude on, A. Mansfield Holmes..... 177
Britcher, Horace W., An Occurrence of Albino Eggs of the Spotted Salamander..... 69
*By-Laws, 1897-98..... 198
By-Laws, 1898-99..... 356

Carcinoma on the Floor of the Pelvis, Two Discoveries in Cancerous Disease, Mary A. Dixon Jones..... 165
Caryophyllales, Contributions to the Histogenesis of the, Frederic E. Clements..... 97
*Claypole, Agnes M., Some Points on Cleavage Among Arthropods.. 74
*Claypole, Edith J., The Comparative Histology of the Digestive Tract..... 68
*Claypole, E. W., Microscopical Light in Geological Darkness..... 8
*Cleavage Among Arthropods, Some Points on, Agnes M. Claypole.. 74
Clements, Frederic E., Contributions to the Histogenesis of the Caryophyllales..... 97

All articles from Volume XIX are starred.

Digitized by Google

Comma or Cholera Bacilli, Experiments in Feeding Some Insects With Cultures of, R. L. Maddox 75
*Comparative Histology of the Digestive Tract, Edith J. Claypole... 83
*Comparative Study of Hair for the Medico-Legal Expert, A, William George Reynolds 117
*Comparison of the Phagocytic Action of Leukocytes in Amphibia and Mammalia, A, John M. Berry 93
*Constitution, Adopted at Rochester, N. Y., 1892 196
Constitution 355
Contributions to the Histogenesis of the Caryophyllales. I. Frederic E. Clements 97
Coons, Henry C., Obituary, Simon H. Gage 28

*Dahlia as a Stain for Bacteria in Sections Cut by the Collodion Method, Raymond C. Reed 182
*Development of Methods in Microscopical Technique, Henry B. Ward 175
*Digestive Tract, The Comparative Histology of, Edith J. Claypole.. 83
Diphtheria Bacillus, Questions in Regard to the, M. A. Veeder, M. D. 81
Disease, The Natural in, Veranus A. Moore 3

Effect of High Altitude on Blood Counts, A. Mansfield Holmes 177
Epithelium, Intestinal, The Regeneration of, In the Toad During Transformation, B. F. Kingsbury 45
Experiments in Feeding Some Insects with Cultures of Comma or Cholera Bacilli, R. L. Maddox 75

Freshwater Investigations During the Last Five Years, Henry B. Ward 261
*Gage, Simon H., Notes on the Isolation of the Tissue Elements 179
Gage, Simon H., Obituary of William A. Rogers 25
Gage, Simon H., Obituary of Henry C. Coons 28

*Hair, A Comparative Study of, for the Medico-Legal Expert, William George Reynolds 117
*Hemospast, The. A New and Convenient Instrument for Drawing Blood for Microscopic Examination, Veranus A. Moore 186
Histogenesis of the Caryophyllales, Contributions to, Frederic E. Clements 97
Holmes, A. Mansfield, Effect of High Altitude on Blood Counts 177

*Infusoria from the Infusorial Fauna of Louisiana, Notices of Some Undescribed, J. C. Smith 55
Infusoria, Notices of Some Undescribed, from the Infusorial Fauna of Louisiana, J. C. Smith 51
Insects, Experiments in Feeding with Cultures of Comma or Cholera Bacilli, R. L. Maddox 75
Investigations, Freshwater, During the Last Five Years, Henry B. Ward 261

Digitized by Google

Jones, Mary A. Dixon, Carcinoma on the Floor of the Pelvis 165

*Kellicott, D. S., The Rotifera of Sandusky Bay. Second Paper..... 43
Kellicott, David Simons, Obituary, A. M. Bleile..... 21
Kingsbury, B. F., The Regeneration of the Intestinal Epithelium in the Toad During Transformation..... 45

*Leukocytes in Amphibia and Mammalia, A Comparison of the Phagocytic Action of, John M. Berry..... 93
*List of Members, 1897-8..... 201
List of Members, 1898-9..... 358
*Loveland, A. E , A Study of the Organs of Taste..... 129

Maddox, R. L., Experiments in Feeding Some Insects with Cultures of Comma or Cholera Bacilli..... 75
Man, Micrometry of Red Blood Corpuscle of, Frank Judson Parker.. 41
Medical Microscopy, A. A. Young..... 87
*Members, list of, 1897-8..... 201
Members, list of, 1898-9..... 358
Method for Preparing Nucleated Blood in Bulk for Class Demonstration, T. E. Oertel..... 49
Micrometry of Red Blood Corpuscle of Man, Frank Judson Parker.. 41
*Microscopical Light in Geological Darkness, The President's Address, E. W. Claypole..... 3
*Microscopical Technique, Development of Methods in, Henry B. Ward..... 175
Microscopy, Medical, A. A. Young..... 87
*Micro-structural Characteristics of Steel, Francis Scott Rice..... 28
*Microtomes, Two Very Simple, Edward Pennock..... 189
*Minutes of the Twentieth Annual Meeting, held at Toledo, Ohio, August 5, 6, 7, 1897..... 190
Minutes of the Twenty-First Annual Meeting, held at Syracuse, N. Y. 347
Mix, C. M., A Rapid Staining Apparatus..... 341
*Moore, Veranus A., The Hemospast. A New and Convenient Instrument for Drawing Blood for Microscopic Examination..... 186
Moore, Veranus A., The Natural in Disease..... 3
Myers, B. D., Picro-carmine and Alum Carmine as Counter Stains... 337

Natural in Disease, The, Veranus A. Moore..... 3
*Notes of the Isolation of the Tissue Elements, Simon H. Gage 179
*Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana, J. C. Smith..... 55
Notices on Some Undescribed Infusoria from the Infusorial Fauna of Louisiana, J. C. Smith..... 51
Nucleated Blood, Method for Preparing, in Bulk for Class Demonstration, T. E. Oertel..... 49

Digitized by Google

Obituary, Henry C. Coons, by Simon H. Gage..... 28
Obituary, David Simons Kellicott, by A. M. Bleile 21
Obituary, William A. Rogers, by Simon H. Gage..... 25
Occurrence of Albino Eggs of the Spotted Salamander, *Amblystoma punctatum* L., An, Horace W. Britcher. 69
Oertel, T. E., Method for Preparing Nucleated Blood in Bulk for Class Demonstration 49
*Officers for 1897-8 and Executive Committee 2
Officers for 1898–9 and Executive Committee.. 2
On the North American Species of the Genus Atax (Fabr.) Bruz., Robert H. Wolcott..... 193

Parker, Frank Judson, Micrometry of Red Blood Corpuscle of Man.. 41
Pelvis, Carcinoma on the Floor of the, Mary A. Dixon Jones 165
*Pennock, Edward, Two Very Simple Microtomes..... 189
Persistence of Bacteria in the Milk Ducts of the Cow's Udder, Archibald R. Ward..... 57
Photo-Micrography with Opaque Objects, W. H. Walmsley..... 189
Picro-carmine and Alum Carmine as Counter Stains, B. D. Myers... 387
*President's Address, 1897..... 3
President's Address, 1898..... 8

Questions in Regard to the Diphtheria Bacillus, M. A. Veeder..... 81

Rapid Staining Apparatus, C. M. Mix..... 341
Red Blood Corpuscle of Man, Micrometry of, Frank Judson Parker.. 41
*Reed, Raymond C., Dahlia as a Stain for Bacteria in Sections Cut by the Collodion Method..... 182
Regeneration of the Intestinal Epithelium in the Toad (*Bufo lentiginosus americanus*) During Transformation, The, B. F. Kingsbury.. 45
*Reynolds, William George, A Comparative Study of Hair for the Medico-Legal Expert..... 117
*Rice, Francis Scott, Micro-structural Characteristics of Steel..... 28
Rogers, William A., Obituary, by Simon H. Gage..... 25
Ross, Mary J., Special Structural Features in the Air-sacs of Birds.. 29
*Rotifera of Sandusky Bay, The. Second Paper, D. S. Kellicott 43

*Sandusky Bay, The Rotifera of. Second Paper, D. S. Kellicott..... 43
*Smith, J. C., Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana 55
Smith, J. C., Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana..... 51
*Smith, J. C., The Sporular Development of Ameba villosa Leidy .. 69
*Some Points on Cleavage Among Arthropods, Agnes M. Claypole.. 74
Special Structural Features in the Air-sacs of Birds, Mary J. Ross... 29
*Spencer Tolles Fund 1897..... 195
Spencer Tolles Fund 1898..... 354
*Sporular Development of Ameba villosa Leidy, The, J. C. Smith.... 69

Digitized by Google

*Stain for Bacteria in Sections Cut by the Collodion Method, Dahlia as a, Raymond C. Reed.... 182
Stains, Picro-carmine and Alum Carmine as Counter, B. D. Myers... 337
*Steel, Micro-structural Characteristics of, Francis Scott Rice..... 28
*Study of the Organs of Taste, A, A. E. Loveland..... .. 129
*Subscribers, 1897..... 207
Subscribers, 1898..... 364

*Taste, A Study of the Organs of, A. E. Loveland..... 129
*Technique, Development of Methods in Microscopical, Henry B. Ward..... 175
*Tissue Elements, Notes on the Isolation of, Simon H. Gage..... 179
Toad, The Regeneration of the Intestinal Epithelium of, During Transformation, B. F. Kingsbury..... 45
*Treasurer's Report for Year Ending July 22, 1897..... 194
Treasurer's Report for the Year Ending August 17, 1898..... 358
*Two Very Simple Microtomes, Edward Pennock..... 189

Veeder, M. A., Questions in Regard to the Diphtheria Bacillus..... 81

Walmsley, W. H., Photo-Micrography with Opaque Objects..... 189
Ward, Archibald R,, The Persistence of Bacteria in the Milk Ducts of the Cow's Udder. 57
*Ward, Henry B., Development of Methods in Microscopical Technique..... 175
Ward, Henry B., Fresh Water Investigations During the Last Five Years..... 261
Wolcott, Robert H., On the North American Species of the Genus Atax..... 193

Young, A. A., Medical Microscopy..... 87

Digitized by Google

The next meeting of the American Microscopical Society will be held in Columbus, O., August 17, 18 and 19, 1899.

Columbus is the central city of Ohio, with excellent railroad connections in every direction. Its hotels are among the best in the State. It is well known as a convenient and attractive city for conventions.

The sessions of the Society will be held in the elegant new Biological Hall of the Ohio State University, which was designed for the special accommodation of the departments of Entomology, Zoology, Anatomy and Physiology, and is fully equipped with all the latest and best apparatus for this work. The building is in design and general appearance one of the most attractive on the campus and is easily accessible from the city hotels. All the facilities of the institution will be placed at the command of the Society, which is thus insured the most satisfactory environment for a successful meeting. By holding the meeting at this place and date, members of the Society are assured of reduced railroad rates, granted in connection with the meeting of the American Association for the Advancement of Science the following week. A most cordial invitation is extended to our members to remain for the meeting of the latter organization and enjoy all its privileges at an added expense of $3.00, the nominal fee for affiliated membership, or to become full members.

Reduced railroad rates are granted to all our members. Details concerning rates, programs, etc, will be sent in a later circular. Notice of papers for the annual meeting should be sent the Secretary at once.

By recent action of the Society, members may be elected at any time, and blank applications may be secured in any number from the Treasurer or Secretary.

Digitized by Google

TRANSACTIONS

OF THE

American Microscpical Society

ORGANIZED 1878 INCORPORATED 1891

EDITED BY THE SECRETARY

Twenty-Second Annual Meeting

HELD AT

COLUMBUS, OHIO, AUGUST 17, 18, AND 19, 1899

VOLUME XXI

LINCOLN, NEB.
HUNTER-WOODRUFF PRINTING COMPANY
1900

Digitized by Google

OFFICERS FOR 1899–1900.

President: A. M. BLEILE . . . . . Columbus, O.
Vice Presidents: C. H. EIGENMANN . . . . . Bloomington, Ind.
M. A. VEEDER . . . . . Lyons, N. Y.
Secretary: HENRY B. WARD . . . . . Lincoln, Neb.
Treasurer: J. C. SMITH . . . . . New Orleans, La.
Custodian: MAGNUS PFLAUM . . . . . Pittsburg, Pa.

ELECTIVE MEMBERS OF THE EXECUTIVE COMMITTEE.

W. W. ALLEGER . . . . . Washington, D. C.
A. T. KERR . . . . . Buffalo, N. Y.
B. D. MYERS . . . . . Ithaca, N. Y.

EX-OFFICIO MEMBERS OF EXECUTIVE COMMITTEE.

Past presidents still retaining membership in the Society.

R. H. WARD, M. D., F. R. M. S., of Troy, N. Y.,
at Indianapolis, Ind., 1878, and at Buffalo, N. Y., 1879.
H. L. SMITH, LL. D., F. R. M. S., of Geneva, N. Y.,
at Detroit, Mich., 1880, and at Cleveland, O., 1885.
J. D. HYATT, F. R. M. S., of New York City,
at Columbus, O., 1881.
ALBERT MCCALLA, PH. D., F. R. S. M., of Fairfield, Ia.,
at Chicago, Ill., 1883.
J. D. COX, LL. D., F. R. M. S., of Cincinnati, O.,
at Rochester, N. Y., 1884, and at Madison, Wis., 1893.
T. J. BURRILL, PH. D., F. R. M. S., of Champaign, Ill.,
at Chautauqua, N. Y., 1886.
GEO. E. FELL, M. D., F. R. M. S., of Buffalo, N. Y.,
at Detroit, Mich., 1890.
FRANK L. JAMES, PH. D., M. D., F. R. M. S., of St. Louis. Mo.,
at Washington, D. C., 1891.
MARSHALL D. EWELL, M. D., F. R. M. S., of Chicago, Ill.,
at Rochester, N. Y., 1892.
SIMON HENRY GAGE, B. S., of Ithaca, N. Y.,
at Ithaca, N. Y., 1895.
A. CLIFFORD MERCER, M. D., F. R. M. S., of Syracuse, N. Y.,
at Pittsburg, Pa., 1896.
E. W. CLAYPOLE, B. A., D. Sc., (Lond.), F. G. SS. L. E. & A., Pasadena, Cal.
at Toledo, O., 1897.
V. A. MOORE, M. D., of Ithaca, N. Y.,
at Syracuse, N. Y., 1898.
W. C. KRAUSS, M. D., F. R. M. S., of Buffalo, N. Y.,
at Columbus, O., 1899.

The Society does not hold itself responsible for the opinions expressed by members in its published Proceedings unless indorsed by a special vote.

Digitized by Google

TABLE OF CONTENTS

FOR VOLUME XXI.

The Annual Address of the President: Some Medico-legal Aspects of Trauma in Relation to Diseased Cerebral Arteries, by William C. Krauss, Buffalo, N. Y. 1

Defective Development and Disease, with Special Reference to the Curability of Consumption and Cancer, by M. A. Veeder, Lyons, N. Y. 17

The Reaction of Diabetic Blood to Some of the Anilin Dyes, by V. A. Latham 31

Comparative Study of the Soft Palate, by William Fairfield Mercer, with plates I and II 41

The Eyes of the Blind Vertebrates of North America, II. The Eyes of *Typhomolge Rathbuni* Stejneger, by Carl H. Eigenmann, with plates III and IV 49

The Modern Conception of the Structure and Classification of Diatoms. With a Revision of the Tribes and Rearrangement of the North American Genera, by Charles E. Bessey, with plate V 61

Notices of Some Undescribed Infusoria, from the Infusorial Fauna of Louisiana, by J. C. Smith, New Orleans, La., with plate VI 87

Notogonia Ehrenbergii Perty, by J. C. Smith, New Orleans, La., with plate VI, fig. 8 95

Chlamydomonas and its Effect on Water Supplies, by George C. Whipple, Brooklyn, N. Y., with plate VII 97

An Incubator for Student Use, by Veranus A. Moore, with plate VIII. 103

Some Laboratory Apparatus, by Simon Henry Gage 107

An Expedient for Use in Difficult Resolution, by R. H. Ward, Troy, N. Y. 111

The Plankton of Echo River, Mammoth Cave, by Charles A. Kofoid 113

Library Expedients in Microscopy. Indexing, Cataloguing, Preparing and Arranging Literature and Slides, by R. H. Ward, Troy, N. Y. 127

New Genera and Species of North American Hydrachnidae, by Robert H. Wolcott, with plates IX to XII 177

A Plea for the Study of Limnobiology, by Henry B. Ward 201

A New Avian Cestode, *Metroliasthes lucida*, by B. H. Ransom, with plates XIII and XIV 213

A Comparative Study of Methods in Plankton Measurement, by Henry B. Ward, with plates XV to XVII 227

Necrology 249

Minutes of the Annual Meeting 257

Treasurer's Report 263

Constitution 265

By-Laws 266

List of Members 268

List of Subscribers 275

Advertisements I

Digitized by Google

ERRATA.

Page 5, fifteenth line from the top: omit the comma between "uraemic" and "manifestations."

" 9, fifth line: insert "r" in "transgressors."

" 99, sixth line from the bottom: transpose "next" and "the."

" 135, top line: substitute "amount" for "mount."

" 148, insert "5i" before "Inorganic Microscopy."

" 158, line "811, 2": for "cyptoplasm" read "cytoplasm."

" 176, top line at right: "Ecuador," for "Equador."

" 207, at bottom: references under "Claypole, A. M." and "Claypole, E. J." should be to "Proc. Am. Mic. Soc."

Digitized by Google

Eigenmann

ORGANIZED 1878 INCORPORATED 1891

MAY, 1900

TRANSACTIONS OF THE AMERICAN MICROSCOPICAL SOCIETY

EDITED BY THE SECRETARY

TWENTY-SECOND ANNUAL MEETING

HELD AT

COLUMBUS, OHIO,

AUGUST 17, 18 AND 19, 1899

VOLUME XXI

Digitized by Google

Digitized by Google

TRANSACTIONS

OF

The American Microscopical Society

TWENTY-SECOND ANNUAL MEETING, HELD AT COLUMBUS, OHIO, AUGUST 17, 18 AND 19, 1899

THE ANNUAL ADDRESS OF THE PRESIDENT

SOME MEDICO-LEGAL ASPECTS OF TRAUMA IN RELATION TO DISEASED CEREBRAL ARTERIES

By WILLIAM C. KRAUSS, M. D., F. R. M. S., Buffalo, N. Y.

In casting about for a subject upon which to address you I thought it wise to select one from the domain of medico-legal medicine, one which has interested me for some time and one which I trust will continue to absorb the interest it so much deserves.

After a period covering ten years of active private practice in the field of nervous and mental diseases, some important facts must certainly stand out prominently to almost any one who is in any way an observer or even a follower in the science in which he treads. The mere pursuit of any of the microscopical sciences must make of any one an observer—one who sees, then feels—not with his fingers but with his intellectual grasp.

In the study of disease one should first search for the phenomena, and then ask for the cause, and in nearly all cases he will find the phenomena commensurate with the cause. Some-

Digitized by Google

times the cause may be obscure—not, however, to the trained and thorough observer, but to him who looks superficially at the nature of things and fails to see what lies below the superficial strata. At other times that cause may be so hidden and so buried within the organism that the microscope, with all its mechanical niceties, is called into action to help solve the seeming mystery.

One of the most interesting questions in neurology, and one of the most important is the relation of trauma to disease of the nervous system. I do not mean a trauma sufficient to produce a fracture if applied to the cranium, or even to a laceration, if applied to the soft tissues, but a trauma apparently slight and of seeming little import at the time of its infliction. To those cases especially do I refer where serious, even fatal, results follow a slight contusion, in certain individuals, while in others the same force would be scarcely if at all perceptible, and this brings me to the important and valuable services to be rendered by the microscope in elucidating the true cause of the various phenomena noted.

It is a well-known fact that the susceptibility of individuals differ; that is, what produces a serious condition of things in one would have no effect upon another. This susceptibility may be evidenced in one of two ways: first, by producing a class of disorders comprised under the head of the traumatic neuroses, usually functional and temporary, and, secondly, by calling forth a more serious class of disorders, which terminate in death itself, either primarily or through sequelæ. Such are injuries to the arterial system, weakened and degenerated by disease, either acquired or inherited. The vices, alcoholism and syphilis, produce upon the arterial walls, especially of the cerebral vessels, a degeneration and disintegration, which render them unsafe carriers of the blood even under the usual, normal blood pressure. When the pressure is increased, the tension becoming greater, then there develop, as Charcot pointed out in 1868, and Virchow previously in 1851, under the name of *ectasia ambulare*, small aneurismal protuberances, which under slight provocation, as shock, excitement or exer-

Digitized by Google

tion, physical or psychical, burst, and permit the egress of blood under the high arterial tension into the surrounding brain tissues.

Of the two classes of disorders the first, or functional, are of less serious import and depend less upon a preexisting pathological condition of the constituent elements of the nervous system than upon a general debasement or deterioration of the whole nervous organisation. There is found in those individuals an increased morbid reaction of the ganglionic nerve centers to all kinds of impressions, both mental and bodily, whether slight or profound, and is liable to manifest itself on very short notice and on the least provocation.

The microscope has been unable as yet to point out the degree of involvement of these nerve centers or even the area of involvement, but may at some future time render inestimable aid in solving one of the most complex questions in human neurology. This very absence of knowledge regarding its pathology has led to much controversy and debate regarding this affection. There are even some who look upon it with contempt under the mistaken idea that the barometric changes of disposition, tastes and feelings from day to day indicate a fraudulent basis. Studied originally by Erichsen, under the name of railway spine, this syndrome has been investigated by Rigler, Hodges, Page, Clevenger, Oppenheim, Strümpell, Dana, Outten, Knapp, Bailey, and in no uncertain way by Charcot and his pupils, and has received a galaxy of names, polyonymic as well as mononymic. The relation which the arterial system bears to the genesis of this affection is as yet not well defined, except in this much, that an artery diseased is a poor conduit for the passage of a fluid whose function in the brain is primarily to nourish and regenerate tired and worn out nerve cells.

Turning to the second class of disorders we meet a condition of the vessel walls long since recognised, and easily demonstrable by any one acquainted with microscopic technique. Doubt and uncertainty regarding the lesion have long since disappeared, and to the student beginning the study of medicine is taught at the bedside and demonstrated in the laboratory the

Digitized by Google

effects of an endarteritis and the structural appearance of the lesion. He is, moreover, taught that this condition of the vessel walls, leading to their deterioration, disintegration and destruction when occurring in early manhood is attributable, in the great majority of cases, to two vices—alcoholism and syphilis—both unfitting the arteries for the work nature originally mapped out for them.

Three conditions are necessary for the normal circulation of the blood in the arterial system. First, the arterial walls must be capable of dilating without strain or injury to any of the coats of the arteries; second, the walls must be able to contract upon their contents; and third, the lumen of the vessels must be preserved.

The elasticity of the vessel walls permits the blood to flow in an unbroken, continuous current through the smaller blood-vessels and arteries, relieving them of the direct force of the heart's action. In fact the main force of the heart is spent in distending the larger arteries and the immediate propelling force of the circulation is the elasticity of the arteries in which the heart stores up the energy of its systole for the moment. The blood pressure is, of course, highest in the heart; considerable in the whole arterial system, though gradually diminishing toward the capillaries, in which it would be feeble; lower still in the smaller veins; and at its minimum where the great veins enter the heart. It is estimated that the blood pressure of the carotids in man is not less than 150 to 200 millimeters of mercury. To supply a sufficient elasticity to the arterial walls, to withstand the force of the heart's action, the middle coat has been supplied with yellow elastic tissue, the importance of which, when diseased, is not to be overlooked or underestimated.

The contractility of the arteries has great physiological importance, but less pathological than the elasticity. In the smaller vessels, by virtue of their contractile walls, the distribution of blood is regulated to the various organs. Where the resiliency of the vessels is at fault, active or passive anemias or hyperemias of the brain and other organs are produced.

When the elasticity and contractility of the vessels are not

Digitized by Google

impeded by disease and the lumen is not encroached upon, nutrition is carried on normally and the functions of the parts supplied are commensurate with their growth and development. Where the vessel walls are weakened by disease, the elasticity of the arteries is impaired, the resistance to the blood pressure is too feeble and hemorrhage from rupture takes place.

The disease leading to the weakening of the vessel walls has been variously designated by different names as arterio-sclerosis, atheroma, chronic endarteritis, endarteritis deformans and the like.

A pure and simple physiological process of old age, its earlier occurrence, or the more extreme grades of its severity, are dependent upon some toxic principle in the organism, prominent among which may be mentioned syphilis, chronic alcoholism, gout, uremic, manifestations, and in some cases it is due to overstrain. Although the causes of arterio-sclerosis are well known, there exists diversity of opinion as to how these recognised causes operate. The opinion once in vogue, that the inflammation started in the inner coats as a result of the irritation of the toxic or infectious agencies in the blood, is no longer tenable. It seems fairly well established that the degenerative changes and loss of elasticity in the vessel wall are the result of the primitive causes, and the hyperplastic processes in the intima and other parts of the arterial wall are the ultimate result. (Stengel.)

Thoma believes that the degenerate vessel tends to dilate and to thereby slow the circulation; the slowing leads to hyperemia of the vessels, and to a consequent connective tissue new formation in the intima, which narrows the vessels. These changes also occur in the middle and outer coats.

Heubner, in 1874, first described accurately the changes taking place in the arteries, especially at the base of the brain, resulting in an arteritis or endarteritis, and found existing either as an independent disorder or as part of a local syphilitic affection. An endarteritis is found, due to the pouring out of round cells from the *vasa vasorum*—an endothelial proliferation, followed by thickening of the intima, fenestrated

Digitized by Google

membrane and adventitia. As a result, the lumen of the vessel is narrowed, even occluded, or the intima becomes roughened and changed and a thrombus forms, which may in turn give rise to an embolus.

The process may be a diffuse one, but it is most commonly distributed irregularly, the inner surface of the vessel exhibiting patches of sclerosis separated by areas of comparatively healthy tissues, or is furrowed or wrinkled with irregularities. In many cases also there occurs a deposition of new material within the affected area of the vessel wall, this newly formed tissue being in some cases hyaline and nearly structureless ("hyaline degeneration"); in others containing round cells, few or many, embedded in a hyaline or gelatinous matrix. This newly formed tissue, furthermore, is very prone to early and extensive, slowly progressive, degenerative changes, fatty, or, less frequently, calcareous in nature, which render the diseased areas more distinctly visible, giving rise to the familiar "atheromatous plaque."

In those cases in which the degenerative change is calcareous in character, the formation of irregular chalky masses, or of smooth "calcareous plates," is a common result. In extreme cases these deposits may involve the entire circumference of the vessel for long distances, rendering the arterial wall so brittle, that instead of bending, it fractures under application of force. The fatty and calcareous degenerative changes are often combined; indeed, in the more serious cases this is the general rule, the deposition of calcareous matter appearing as a later stage of the fatty degenerative atheroma.

The patches of atheroma are raised, usually encroaching slightly upon the lumen of the artery, although in ordinary cases they interfere only in a very minor degree with blood-flow.

There are three alterations which atheroma produces, each of which may, according to circumstances, have important effects on the circulation.

These are narrowing of the caliber, loss of elasticity and rigidity of the wall, and interference with the muscular con-

Digitized by Google

tractility of the vessel. Thus it is seen that this process counteracts each one of the conditions so necessary for the normal circulation of the blood. Generally as a result of the weakening of the vessel walls by sclerosis or degeneration, small saccular aneurisms, often called miliary aneurisms, develop in the end arteries of the brain, but especially in the arteries supplying the optic thalamus, corpus striatum and lenticular body, and the lenticulo-striate artery has even been designated by Charcot the *apoplectic artery*, because of its proneness to aneurismal development and consequent rupture.

Hemorrhage rarely occurs at the cortex of the brain because the smaller arteries and arterioles enjoy an intimate anastomosis with each other, and any sudden increase in blood pressure is quickly equalized through this anastomosis. Then, too, these arteries do not receive the direct flow of the blood from the carotids, and the blood pressure is perceptibly diminished by the time it reaches these arterioles. Arteries at the base of the brain are not so liable to rupture as the end arteries going to the large ganglia, because of their anastomoses in the circle of Willis and because of their tortuous course, which permits of considerable increased pressure before they straighten out and become tense. Aneurisms of small size, from a pea to a bean, are very prone to develop along these arteries and hence are next in importance to the lenticulo-striate artery as regards rupture.

The end arteries in the region of the internal capsule are so liable to rupture, because instead of having a system of anastomoses, they terminate in blind pockets.

When the large vessels at the base of the brain, that is, of the middle cerebral, posterior cerebral and the communicating arteries, have undergone calcareous degeneration the absence of the normal elasticity of these vessels allows the blood to pass with great force and directness into these end arteries and if the conditions are favorable, that is, an endarteritis is present, the vessel walls will yield to the strain and become bulbous and then aneurismal. They may remain in this condition for some years even, but they are comparable to the faulty flues in

Digitized by Google

a boiler—only safe as long as the pressure is low. When the pressure is increased physiologically, through eating, drinking, sexual congress, exercise, or pathologically, through stimulants, the emotions, or by slight injuries to the head, then the aneurismal walls give way and a serious hemorrhage follows.

Without previous disease of the arteries it is almost impossible to think of hemorrhage from rupture to take place. The action of the heart alone is never responsible. In most of these cases where the endarteritis has existed for a long period, the heart is hypertrophied, a condition probably due to the resistance which it has to overcome in forcing the blood along through the diseased and often narrowed vessels without the aid of the normal elasticity by which the work of the heart is much lessened.

To an individual with such a diseased condition of the cerebral arteries, a trauma, be it ever so slight, may, and does very often, produce fatal hemorrhages. When such cases arise in the criminal courts, what is to decide the true guilt of the prisoner? Should the jury listen only to the passioned, eloquent summary of the prosecuting attorney, or should the jury take cognizance of the status of the cerebral vessels of the victim previous to the injury, and heed the testimony of the microscopist, who has carefully examined into the condition of the arteries and found the prisoner, though guilty, nevertheless a victim of circumstances?

There is an old story told of a physician, who, when being asked his age, replied that he was as old as his arteries. How true this is, those of us who feel of arteries can bear testimony, but is it not equally true, that a man is no healthier than his arteries? Here again, those of us who examine applicants for life insurance know full well that no individual with a sclerotic radial or temporal artery will be accepted as a first-class physical risk. If a condition of sclerosis exists at the wrist or forehead, it is safe to infer that the same condition will be found at the base of the brain. It has even been asserted by Duret that endarteritis will be found affecting the basilar artery when its presence can be detected in no other artery of the body.

Digitized by Google

If life insurance companies regard such individuals as sub-standard risks, why should not courts of justice? I do not make this plea because I favor the criminal classes or desire to lighten their punishment in any degree, or to offer any inducement or incentive to future transgessors, but simply to call attention to a question which I believe will in the near future be given full and due consideration.

A chain is no stronger than its weakest link, or a bridge stronger than its weakest span, or a man stronger than his weakest artery.

If a man with such a condition of the arteries be engaged in heated discussion, in mental or physical excitement, or is under the influence of alcoholic drinks, or all combined, and is suddenly stricken down with a fatal hemorrhage, the verdict will simply read, death from apoplexy. If, however, he is engaged in a dispute, under the same conditions as just noted, and receives a slight blow, perhaps even a push by his antagonist, and a fatal hemorrhage likewise ensues, the verdict will read murder or manslaughter, and the prisoner will most generally receive the full punishment allotted by the statute. A case of this kind, in which I was engaged as medical expert, but failed for some reason to appear on the stand, illustrates the injustice of such procedures, and although perhaps not admissible in an address of this kind, nevertheless I will report it and grant you the exceptions.

The victim was a sailor of Swedish extraction, and had sailed the lakes for seven or eight years, making his home at Buffalo. He was in the habit of spending his nights when on shore at a notorious dance hall in the infected district. One night he met a singer in the resort, whose husband was "the strong man," doing certain tricks, as stone-breaking, tearing chains asunder and the like. The couple proceeded up-stairs to a private room and drank heavily of strong liquors. Leaving the room and descending the stairs they met the husband, who struck the sailor on the jaw, felling him, and in a few moments the latter expired. Post mortem examination of the cranial cavity revealed a large flattened clot of blood in the posterior fossa of

Digitized by Google

the cranium—the same having escaped from a large opening in the basilar artery near its bifurcation into the posterior cerebrals. The basilar artery was the seat of an arteritis, also endarteritis, with thickening of the lumen in some places and thinning in others. It was at one of the thinned portions that the rupture occurred. Other evidences of cerebral or arterial disease were wanting, and the anatomical diagnosis was reported as "cerebral basilar hemorrhage."

Of course, no history of syphilis could be obtained, but the seat of the disease, condition of the artery, occupation, habits and surroundings of the man, leave little doubt as to some previous specific inoculation. No doubt the woman's husband was, to a great degree, a victim of circumstances. With the degenerated condition of the arteries, as was found in the case, the excitement might of itself have produced the arterial rupture, and this, further accentuated by the increased arterial tension, due to the large amount of stimulants which he had taken, would have required but a very slight shock, either mental or physical, to have produced a disruption of the diseased vessel. The force of the blow was of itself not so important under these circumstances, although at the trial much stress was laid on the assumption that the prisoner must have dealt a terrible knock-out blow, being noted for his strength, which, in fact, consisted only in stage tricks, he being actually possessed of only ordinary strength.

There was no examination made microscopically to determine the exact pathological condition of the bloodvessels. Neither was the defense of the prisoner as vigorously fought as might have been, on account of the evil atmosphere surrounding the tragedy, and the verdict of the jury read, manslaughter in the first degree. Had the microscope been called into this case, the arterial degeneration probably present been thoroughly demonstrated to the court, the defense of the prisoner carried out on lines suggested above, I believe the disposition of the case would have been different, even though it was of unsavory character.

Soon after I was called in to another medico-legal case which, with your kind permission, I will also briefly narrate.

Digitized by Google

A policeman making his rounds in the lower part of our city came across a group of children surrounding a drunken man, who had fallen to the ground. In trying to rouse him, the man suddenly sprang to his feet and attacked the policeman, so that the latter was obliged to defend himself, and in the fray, struck the drunken man on the head with his club. The man staggered and fell to the ground. An ambulance was called and he was taken to an emergency hospital for treatment. No fracture of the skull was found, and no abrasion of the scalp could be detected, but the patient was in a condition of coma—very light—which increased gradually to a deep coma. A meningitis was supposed to be the cause of the coma and after an illness of two weeks he died. The autopsy, made very carefully, did not reveal any meningeal inflammation, but on careful inspection a small aneurism with hemorrhage into the medulla was detected. The brain and arteries were carefully hardened and prepared for microscopical examination, which was conducted by Dr. H. U. Williams, of Buffalo, representing the prosecution, and by myself for the defense. No trace of any injury to the meninges could be found. The brain matter was healthy; not so, however, the arteries. A general endarteritis was found affecting nearly all the cerebral arteries, but more especially the vessels at the base of the brain—the vertebrals and the basilar. The middle coat of the vessels was unequally thickened and thinned and a small aneurism had developed near the junction of the basilar and vertebral arteries. This aneurism was furthermore ruptured and the pressure of the escaped blood upon the vital centers in the medulla occasioned the man's death.

At the trial, the medico-legal question of most import was, in how far did the blow of the policeman's club produce death? Had the arteries been in a normal healthy condition there would have been no contest over the case, no point of difference to be settled. The condition of the vessel walls, however, put another aspect to the case. Who could say but what the excitement and the consequent increased arterial pressure

Digitized by Google

might not of itself have produced a rupture of the diseased vessels. The microscope proved conclusively a dangerous condition of the ruptured vessel and case after case has been found of a similar death without any external violence. It was therefore impossible to state what brought about the rupture and the jury wisely exonerated the policeman from the charge brought against him.

Diseased conditions of the cerebral arteries, especially produced by alcohol and syphilis—place individuals into a class peculiarly of their own. They are dangerous to themselves and far more dangerous to others. They offer a point of least resistance, and upon the degree of resistance does their own life and safety depend. They are no stronger, no healthier than their diseased vessels and should be so regarded in all courts of justice.

A trauma not severe enough to produce any pain or injury to a normal healthy man will produce brain lesions of the most dangerous character in these cases. Where the condition of the arteries is not made manifest to the court by a microscopist, or where the court fails, or refuses, to see the susceptibility of the patient to apoplexy through slight injuries, then the prisoner receives punishment far in excess of what he really deserves. All cases of death following head injuries should be most carefully investigated and the true condition of affairs be made known in no uncertain manner. The microscopist becomes in all such cases a most important adjunct, and his findings and deductions should be given most careful and respectful consideration.

Turning now to another class of symptoms engendered by trauma to the head, we meet disturbances of mental action, sometimes slight, sometimes profound, and in not a few cases of beginning degenerative lesions, terminating in insanity. It is not so much the local effect of the injury, but the general effect of a *commotio cerebri*, and the syndrome of mental disorders induced by such cause has been well termed by the Germans "commotion insanity." The effect of a violent blow or jar or jolt to the head must have some influence upon the mol-

Digitized by Google

ecules of the brain, as well as upon the encephalon as a mass; it must displace and disarrange delicate microscopic structures, such as the nerve cells and nerve fibers.

If there be present in the individual the remnant of previous syphilitic inoculation, the effect will be far reaching and most serious. A slumbering paresis is many times awakened by slight accident so infinitesimal that at the time no heed is paid to it. Slowly and surely the progressive symptoms of paresis develop and soon the disease is converted into a galloping paresis, and fortunately for the patient and friends a rapid dissolution is to be looked for. The microscope again discloses the cause, as Mickle, of London, Mendel, of Berlin, and many others have long since shown—a degenerative condition of the frontal lobes with a previous syphilitic inoculation as a background.

General paresis, like tabes, has an initial stage that may last for months or years, during which the patient is not only not incapacitated for work, but may conduct himself so rationally that no suspicion is entertained that he is already suffering from a disease which is soon to destroy both body and mind. From the insidiousness of its onset it is usually impossible to say even approximately when the morbid process began. In non-traumatic cases, where the first marked symptoms consist of an attack of acute maniacal excitement, or of acute mental depression, there is every reason to suppose that the disease had already existed, though unsuspected, for sometime. Similarly, when an injury to the head is quickly followed by an outbreak of the symptoms of the disease, it is never possible to say with absolute certainty that the traumatism did anything more than hasten into activity a process which was already existent and whose ultimate development was inevitable, irrespective of traumatic agency. (Bailey.)

This early prodromal stage, when the individual is thought by friends and relatives to be perfectly sound and healthy, is called by LeGrand du Saulle the "medico-legal period," because of the large number of medico-legal inquiries made bearing upon the patient's soundness of body and mind during this

Digitized by Google

period. I recall a case where in such a predisposed individual paretic symptoms rapidly developed after he had been knocked down on a street corner by a careless driver. Previous to this accident he was a thorough musician and an adept violinist. After a few days he became a paretic of the most pronounced type with his delusions of grandeur all concentrated about music, opera and song. The family, on advice of the consulting attorney, had recourse to law and a suit for damages was the result. Trauma was looked upon as the cause of this man's insanity, but as a matter of fact it was only contributory. The real cause was the pathological condition existing in the poor fellow's brain—a product of his own misdeeds. The trauma only lit up the slumbering embers, and once flared-up the progress of the disease was not to be controlled.

The percentage of cases of paresis due to trauma is given by Schlager* as "one-seventh of all cases of mental diseases induced by head injuries." Meyer found 15 cases of injury to the head in 76 cases of general paresis in which the causes were clearly made out. In 80 male cases Krafft-Ebing found cranial injury to be the cause in 6. Christian observed 43 cases of general paresis in 100 cases of injuries to the skull. Other observers, as Mickle and Gudden, have found a relationship between trauma and general paresis in 7-10 per cent. of their cases.

In the great majority of these cases the head injury is but secondary to the predispositions underlying the individual. These may be either inherited or acquired. If the former, then a congenital syphilis; if the latter, a preceding syphilitic inoculation is, as a rule, the predisposing factor. Generally, and if the courts are ill-advised and ignorant of the underlying condition, punishment is inflicted, usually in the shape of heavy damages awarded the patient.

The rôle which the diseased bloodvessels play in paresis is perhaps primary, leading to the atropic changes in the brain cortex itself. The very earliest anomalies are nutritive defects in the ganglionic cortical elements, and then follow local hyper-

* Quoted from Bailey; Accident and injury.

Digitized by Google

emias of the frontal, temporal or parietal convolutions, dilatation and degeneration of the coats of vessels, lymphatic stasis and effusions into perivascular lymph spaces, swelling and then wasting of nerve cells and fibers, proliferation of neuroglia and of protoplasmic glia cells, cortical and meningeal adhesions, and the formation of neo-membranes.

Thus it will be seen that although differing materially from the pathological condition of the arteries, as found in apoplectic attacks, nevertheless, the degenerative coats of the artery, through syphilitic infection, are equally as dangerous to the victim and as calamitous to the aggressor.

Alcohol and syphilis, the two vices of civilization, produce the most degenerating conditions in the neuron and in the vessels going to support and tone the system of neurons. Disease and death follow closely upon their trail; they single out with great delight both youth and beauty; they render the strong and vigorous weak and susceptible; they disintegrate and destroy the physical, as well as the psychical; but more than all, not satisfied with their own unfortunate prey, they tend to inculpate others by force of circumstances and weave a web of guilt and suspicion about them. Fortunately, however, in many cases they leave such glaring earmarks that the microscope is able to detect their presence and act thereby as a safeguard to the unsuspecting and innocent.

Digitized by Google

Digitized by Google

DEFECTIVE DEVELOPMENT AND DISEASE, WITH SPECIAL REFERENCE TO THE CURABILITY OF CONSUMPTION AND CANCER.

By M. A. VEEDER, M. D., Lyons, N. Y.

The problems about to be discussed are of interest to microscopists, although in one sense more strictly adapted to another audience. It would have been desirable to have given more detailed observations in reference to histological, biological, and other points involved, instead of dwelling so largely upon the general aspects of the subject. Nevertheless, the paper may be, I hope, of some service to the working microscopist as indicating lines of research that it is specially desirable to follow.

Our knowledge of the agency of bacteria in the production of disease has advanced so rapidly since the pioneer discovery of the bacillus of tuberculosis in 1883 that there is danger of forgetting that there is another side to the question, having reference to the perfection of organization of the human frame, and its consequent resisting power to disease. Indeed, there are disease conditions due to defective development solely, in the entire absence of bacterial infection of any sort. Thus the degenerative changes due to old age result in enfeeblement amounting to positive disease, and yet there is no microbe of old age, at least not any thus far discovered. Nor is there any microbe of nearsightedness, nor of squint, nor of harelip, nor of lack of brain and nerve, nor of any of the thousand and one imperfections and peculiarities, many of them racial, like flat noses and thick lips, that appear in those having otherwise fine physique.

Really the human body is no better than patch-work, loosely put together and weak at many points. Malformations about the neck, commonly spoken of as scrofulous, may signify noth-

Digitized by Google

ing more than imperfect closure of the embryonic bronchial fissures in that location. The tibia and fibula being of nearly equal size, and the ankles crooked in the embryo, undue persistence of these forms may originate coarse ankles and clumsy gait, presenting the appearance of positive disease, whereas it is a purely developmental defect. So, too, the appendix vermiformis, that supernumerary tattered end of the patch-work of the body, appears to serve no purpose except to catch dirt and infection, and destroy life on absurdly small provocation, gratifying the disciples of Malthus, but no one else. In like manner the wisdom tooth is a superfluity, except so far as the dentist is concerned, and there are many other abnormalities of like character pleasing to no one, unless it be the student of teratology, and the surgeon.

In the subject chosen for this paper, cancer and consumption are specially named in connection with defective development, as representing two aspects of the entire question, and at the same time as being essentially most important because of their serious nature. With our present knowledge, cancer represents all that is worst among diseases not due to specific micro-organisms, and consumption all that is worst among diseases produced by such organisms.

Until inoculation experiments have demonstrated that cancer is contagious, its bacterial origin cannot be assumed. Cancer appears to be most closely allied to eczema, the chief difference being that it affects epithelial cells other than those chiefly involved in eczema. Cancer, like eczema, may be produced by many sorts of irritation, bacterial or otherwise, there being no specific parasitic organism in either disease, and both alike being non-contagious. Thus, tobacco-smokers' cancer starts from the irritation of the lip by the pipe, at the outset resembling the eczema to which it is so closely allied, and which is associated also with cancer of the breast, as was pointed out by Sir James Paget. The difference in the behaviour of cancer and eczema in respect to danger to life is, according to this view, due to the fact that in the former the epithelial cells involved have a power of growth resembling that of various appendages of the skin,

Digitized by Google

such as the hair and nails, but not safeguarded in the same way. Cancer cannot be cast off as the horse sheds his coat, or the stag his antlers, or the snake its skin, nor can it be kept trimmed, like the hair and nails, although something of this sort is often attempted surgically.

Thus cancer may be taken as the type of all that is worst in the diseases due to faulty growth. It does not stop with the formation of tissues of low vitality, and specially vulnerable to the forms of infection capable of producing ulceration, but goes right on increasing in bulk, producing injurious pressure effects on surrounding parts and destroying their vitality. The products of the perverted cell activity in cancer, like many other wastes of the body, appear to be poisonous when retained, not resembling, except in appearance, the corresponding exudation in eczema, which is harmless. Thus the epithelial origin and type of growth of cancer is the most serious phase of the question as to the nature and consequences of defect of development affecting the cellular structure of parts of the body.

Consumption, on the other hand, is the type of all that is worst in the class of diseases that are plainly due to specific forms of bacterial infection. Unlike the bacilli of many other infectious diseases, that producing consumption is not destroyed by the products of its own activity. Hence the futility of the search for an anti-toxin for this disease derived from its bacillus, and hence also its tendency to progress to a fatal termination. Self limited diseases only are likely to be controlled to any important extent by the methods of serum treatment thus far devised.

Thus broadly these are two types of disease, the one primarily due to defect of development, and the other to specific bacterial infection. The former produces abnormal growth, which may be harmless, like a wart, or malignant, like cancer; the latter produces the congeries of symptoms comprised under the general term inflammation.

The former of these classes of diseases may exist independently of the latter. There may be hereditary or congenital tissue conditions originating idiocy, epilepsy, deafmuteism,

Digitized by Google

dwarfishness, malformations, and the like, without bacterial infection of any sort. It is a question, however, whether bacterial diseases can gain a foothold, on the other hand, except at some point where there is lowered resisting power, through defect of development. As a matter of fact a very large proportion of the infectious diseases attack primarily portions of the body exhibiting deficiencies in respect to function or structure, or both. It is of fundamental importance to inquire in what way and to what extent imperfections of development are associated with diseases of every kind, excluding none, bacterial or otherwise. Hence the propriety of discussing both consumption and cancer in this connection.

The identification of the markings indicating persistence of rudimentary and embryonic forms is the first step towards a proper understanding of the questions of cellular pathology involved. Such identification is not difficult in a large proportion of cases. Thus the tonsils are rudimentary structures, tending to disappear as adult life approaches, and having little if any function at any time, and consequently having small resisting power, are the usual starting point of disease in the throat. In like manner in the mouth the wisdom tooth is well nigh functionless and specially subject to decay. In the chest the thymus gland reaches its maximum size at the age of two years, and nearly disappears at the age of twenty, and has very little apparent function. This being the fact its agency in the production of disease is worthy of far more careful scrutiny than it has thus far received. In a few instances this gland has been found to be inflamed and swollen where children have died suddenly and unexpectedly without any other conspicuous symptom than some difficulty of breathing. Like the appendix vermiformis, another of these troublesome rudimentary structures, until recently thought to be quite inoffensive, the thymus gland may play a much more important part as a cause of death than has heretofore been supposed. Thus also cretinism is a form of stunted and irregular growth due, apparently, not to bacterial infection, but to imperfection of the

Digitized by Google

thyroid gland as shown by the improvement that results from thyroid feeding in these cases.

Embryonic and rudimentary markings in general are closely related to disease processes. In a case observed by the writer cancer dissected out accurately the surfaces which form the upper bronchial cleft in the embryo, and whose imperfect closure produces harelip and cleft-palate. Erysipelas has been observed to follow the line of these clefts also. In like manner decay in the teeth and bones follows epiphyseal and other lines connected with processes of development. In each case of this sort the spread of disease appears to have had reference to lowered resisting power of the tissues rather than to distribution of blood supply, or to lymphatic channels, or any other like agency.

So too in the case of organs and parts of the body that fail of their normal development there is increased susceptibility to disease. The eye that is congenitally imperfect is specially subject to inflammation. The ear that does not hear well through malformation is most readily attacked by disease. Incomplete closure of the opening that exists normally previous to birth, between the two sides of the heart, entails increased liability to serious consequences from disease, an ordinary cold, it may be, proving fatal in such children. Failure of development of parts of the nervous system may disturb mentality, nutrition, muscular action, and the like. Thus there is not an organ or part of the body that may not exhibit deficiency and consequent disease.

Embryology, especially, throws a flood of light on questions such as these, and becomes an exceedingly fascinating study, as a department of microscopical research. In other words it is not altogether a question of bacteriology, but of the study of the tissues at various stages of their growth and in their various relations. Indeed in the case of cancer this may prove to be the only means of solving the problem of its causation. If it is not due to any specific micro-organism, there is no other resource than to institute a careful search for rudimentary, functionless or disappearing organs or structures in the

Digitized by Google

tissues that are found to be specially subject to cancerous disease. In this connection it is of special interest to note that cancer, unlike infectious diseases, is most apt to occur late in life, pointing to degenerative changes rather than bacterial invasion as its cause.

Still, if cancer should be found to be due to a parasite of any sort it would be none the less important to determine the conditions of lowered resistance which enable it to gain a foothold in the manner indicated throughout the course of the present discussion.

We have at Buffalo, N. Y., a State Laboratory specially devoted to research in regard to cancer. This is a step in the right direction, and it would seem that similar original research in regard to a multitude of questions concerning consumption would accomplish more than such ordinary State Sanitaria for consumptives as have been proposed. It has seemed to the writer, also, that improved methods of recording cases might be of great service in many state institutions.

For years the writer has made it a practice to identify and note, as far as possible, all the markings, even the most insignificant, indicating defective development. Not unfrequently the results are exceedingly interesting, especially when such stigmata are numerous though not conspicuous. For example, a person met casually was seen to have a slight cleft in the iris just below the pupil of the eye. The bridge of the nose was hollowed and of the infantile type. The bony bridge across the lower part of the outlet of the nostril was lacking, the upper lip sinking in at that point. There was evidence of a tendency to harelip in the center of the lower lip, which is rather uncommon, the upper lip being the ordinary location of such malformation. The upper jaw was imperfectly developed, being small in comparison with the lower jaw. The teeth were irregular, and the skin and hair coarse. Darwin's tubercle was specially well marked on the inner margin of the rim of the ear. The neck was thick and of the type sometimes called scrofulous. These and other markings, many of which caricaturists seize upon and exaggerate habitually, would give even

Digitized by Google

the most casual observer the impression that the individual in question was of a low order of development, both physically and mentally. As a matter of fact he was an epileptic, and a criminal, and has since died of consumption.

The disease history in any such case, taken in connection with the record of such markings, becomes very instructive. By such means it may become possible to identify much more perfectly than has been the rule heretofore, the precise defects of development which give access to each particular form of disease, thus affording a basis for more accurate histological study.

Indeed, almost every form of disease, as well as cancer and consumption, exhibits a marked predilection for particular organs and parts of the body. Much light will be thrown upon such selective affinity of disease by studying the relation of the parts involved to embryonic forms and to homologous structures and tissues in animals, and especially to the markings indicating defective development. This is the office of comparative pathology, which bids fair to become a very progressive department of medical science in the near future.

It is possible that the time may come in the course of such investigations as have been outlined when early and complete removal of the part affected will not be our only resource in dealing with cancer. It is not likely that an anti-toxin will be found for cancer, it, like consumption, not being a self-limited disease. Still the writer has seen a cancerous ulcer heal as the result of its becoming the seat of an attack of erysipelas, but the relief was only temporary, the ulceration recurring in about a year and finally causing death. From some microscopic observations that were made in connection with this case it was inferred that the cancer itself was not affected favorably or otherwise by the erysipelas, the real effect that produced the apparent improvement being nothing more than the healing of a subsidiary ulceration due to some form of infection that had fastened itself on the cancerous area. In other words, the erysipelas in this case acted on the principle of an anti-streptococcus

Digitized by Google

serum so far as the ulceration was concerned, but did not really benefit the cancer itself.

So far as the prophylaxis of cancer is concerned, we can only recommend the avoidance of sources of irritation, like the smoker's pipe in tobacco cancer. Peculiarities in regard to the geographical distribution of the disease that are just beginning to attract attention may afford a clue to racial and other hereditary influences on which it may depend. The effect of environment on developmental conditions is very decided, and may play a part in preventing or accelerating the spread of cancer. These questions are very large and difficult, and their complete solution will require extended research along the lines that have been sketched with a free hand in the course of this paper.

Consumption, on the other hand, belongs in the class of bacterial diseases with reference to which the case is much simpler. Still it has its developmental relations, having a marked predilection for particular lung and bony tissue. It is probable that lowered resisting power in these parts of the body is necessary in order that it may gain a foothold. Thus predisposition on the part of the tissues is requisite, as well as presence of infection, as has been indicated throughout the course of the discussion. The bacillus does not pass from parent to child by heredity, but only special vulnerability of the tissues in which it gains a lodgement. Thus whatever tends to secure perfect development, and fortify resisting power, will aid in the prevention and cure of consumption also.

But this is not our only resource. Consumption is a perfectly curable disease in a large proportion of cases, because of certain peculiarities of the bacillus on which it depends. This is the fact in the earlier stages of the disease more particularly. As has already been intimated, there is no anti-toxic serum that is likely to be effectual against it. Nevertheless, consumption is curable in a very simple way, which as soon as it is mentioned, will seem so very obvious that it will be understood and corroborated by experiences within the range of observation of almost any one. And yet this is practically the first public

Digitized by Google

announcement of the result of studies leading definitely to this conclusion.

The point is that the bacillus of tuberculosis thrives only at a temperature closely approximating that of the human body. At a lower temperature, especially, its growth is retarded to such an extent that it may become dormant and in this condition be destroyed by the processes akin to digestion that are going on constantly in the air passages and lungs. Or, at a later stage, if it have invaded the tissues more deeply, it may be destroyed by the leucocytes and other vital agents whose office it is to enable the human frame to resist the invasion of disease.

That it is possible to lower the temperature of the lungs to a considerable degree by the inhalation of air such as is met with in ordinary outdoor living may be shown by a simple experiment. It is possible to arrange a thermometer in a tube, and so regulate the breathing as to obtain very nearly the temperature of the air exhaled. If this be done in air at the ordinary temperature of a room it will be found that the air that has passed through the lung does not quite reach the temperature of the body, but comes very near it if the room be very warm. If then the experiment be tried outdoors in much colder air it will be found that the air exhaled may fall short as much as fifteen or twenty degrees of reaching the temperature of the body. If the bacillus is anywhere in contact with air so cold as this its growth must certainly be greatly retarded and there is very good evidence that this is the fact in the lung. It is probable that the bacillus is located very superficially in the mucous lining of the air passages for a long time, it may be for weeks and months after infection, acting like foreign matter such as dust in this location, until growth begins and the tissues are invaded superficially at the outset but more deeply later. If at this stage the individual infected houses himself up in a warm room constantly, because of the slight hacking cough, as is very apt to happen, the infection gains a firmer foothold, and the chances of recovery diminish steadily. Hence the desirability of outdoor life for consumptives, and plenty of fresh cold air at night. Hence also the advantage of

Digitized by Google

residence at a considerable altitude, the dry air taking up heat more readily, and its rarefied condition quickening and deepening respiration, so that the air cells are more fully expanded and more deeply penetrated. Hence also the comparative immunity from consumption and other lung troubles in the Arctic regions, although this has been ascribed to cod-liver oil, which fails of any such effect in lower latitudes, it being the crisp cold that really does the good. It is the explanation of such benefit as is derived without clear understanding of the reasons, perhaps from living on a ranch, or going to some distant sanitarium, or taking a sea voyage, in all which cases some measure of outdoor life is insisted on. Even within the tropics outdoor life, night and day, may prove effectual on the principle that has been stated.

In order to secure the greatest benefit the vital forces should be strengthened by plentiful and nutritious diet, forced feeding in fact. The change to habitual outdoor life and sleeping in a cool room should be made so gradually and with such precautions as will obviate lowered resisting power through shock to the nervous system.

Many instances are known to the writer in which there has been recovery from consumption affecting the lungs, and instances likewise in which there was failure because the disease was situated in the bones or elsewhere, in such manner as not to be accessible to the benefit from open-air life that has been described.

In this connection it is of very great interest to note that cattle are specially susceptible to infection by the bacillus of tuberculosis, but that it does not affect the lungs in their case so frequently as in the human species, the reasons for which will appear in the further course of the discussion, it depending in part, perhaps, upon the manner of their infection, and in part upon their manner of living.

Normally the temperature of the ox is somewhat higher than that of man, so that cattle are more readily infected for this reason. But growth of the bacillus in the lung would be retarded by their outdoor life at certain seasons, so that as a rule

Digitized by Google

they succumb to tubercular disease scattered in other parts of the body. Horses, on the other hand, are immune, their temperature normally being somewhat below that of man, and their lungs fully and freely expanded in the open air at frequent intervals, instead of being almost entirely disused as in the case of cattle confined to their stalls for weeks and months together, and at best only walking slowly about in the open air. As a matter of fact, cattle that run wild on the plains are as free from tuberculosis as horses. Lecturers at dairymen's conventions, who tell the farmers that they must keep their cattle warm if they would secure record yields of milk and butter, are responsible for much of the spread of tuberculosis.

But perhaps the greatest danger of all is from the common barn-door fowl. The prevalence of tuberculosis among gramivorous birds, whose temperature is normally 105°, is very significant from the point of view of the present discussion. Their flesh is not eaten raw, nor do they yield milk, so that there is no great danger to the human species from tuberculosis in fowls, but their droppings falling into the hay and grain become a source of great danger to cattle especially, whose intestinal tract is most liable to infection from this source. Indeed, this may be the explanation of the reinfection of herds on farms where they have been slaughtered, wholly or in part, in response to the tuberculin test.

The idea of controlling the activity of disease-producing bacilli by temperature changes has other applications already in use that are corroborative of the position here taken. Thus the treatment of typhoid fever by cold baths, or by the application of cold to the abdomen, is in successful use. In like manner the application of cold to the chest has been employed in pneumonia. So, too, the warmth of a poultice may hinder the activity of certain bacilli by raising the temperature beyond the point at which they are best able to grow.

In short, the principle is that employed by Pasteur at the very outset of his studies which originated the modern science of bacteriology, when he hit upon the idea of employing cold to prevent fermentation in beer. He likewise made the dis-

Digitized by Google

covery that the bacillus of anthrax, which is fatal to cattle, horses, and sheep, does not propagate at a temperature very much above 100°, and hence birds, whose temperature normally is 105°, are not susceptible to its attack, unless made to stand in cold water long enough to lower their temperature to the proper degree.

Thus, as every working microscopist knows, temperature control plays a part that can be measured with precision in determining the activity of microbes of every sort. It is to be remembered, however, that the bacillus of tuberculosis is not destroyed in a culture outside the body by a degree of cold that proves fatal in the lungs. It is the resisting power of the body that destroys and eliminates the germ, benumbed and weakened by lowering the temperature. It is to bring out this point clearly that it has been thought best to outline the entire subject of defective development and disease, employing cancer as a typical case in contrast to consumption.

From the point of view of the present discussion it is evident that much of the advice given consumptives in regard to change of climate, outdoor life, and the like, involves some dim idea of the nature of the truth of the matter, but lacks precision, not specifying accurately which are expected to be curative of the measures suggested. With a better understanding in this regard it becomes possible to increase the efficiency of the measures employed, it being known precisely what it is proposed to accomplish. Thus it may become possible to prevent tuberculosis in cattle, as well as in the human species, by proper outdoor exercise of herds and prevention of infection from such sources as fowls.

With these points in view it becomes possible to estimate more accurately the value of various accessory measures, some of which have been hinted at. Experiment has shown that it is possible by forced feeding to determine the sex in bees and tadpoles very readily. It has been claimed recently that this has been accomplished also in the human species. This being the case, it shows what a profound effect nutrition has upon the vital and reproductive organs, and upon heredity. If it is pos-

Digitized by Google

sible to modify the development of sex by such means, it surely is possible to modify in like manner the resisting power of the body against disease.

As regards heredity, Weissmann in his book on "Germ Plasm" makes it consist in the minute subdivision and transmission from parent to offspring of certain protoplasmic granules. If, however, life be taken away in such manner that the protoplasmic constituents of the body are otherwise undisturbed, the form remains but power is wanting. Brain and nerve force manifest in muscular action, and in the operation of the senses, are requisite for the maintenance of bodily vigor in the individual, and for its transmission to the offspring.

Thus the cure of consumption in the manner that has been described is not a question of cold storage, or life in a cave at a constant temperature, with a view to the absolute freezing out of the germs of such disease. It is rather a question of the full and free exercise of the powers of the body, and their maintenance in such condition that, with some aid from special measures of temperature control, they are able to win a complete victory in a contest that has heretofore been very unequal.

It is to be hoped that observers having the requisite microscopical equipment will be specially alert in regard to the questions that have been raised. It is not a question of lenses altogether, but of knowing what to look for.

Digitized by Google

Digitized by Google

THE REACTION OF DIABETIC BLOOD TO SOME OF THE ANILIN DYES.

By V. A. LATHAM, M. D., D. D. S.

The importance of the clinical investigation of the blood is fast becoming an evident factor in the medical and chemical education of to-day, and it seems surprising that so many recent manuals pertaining to clinical methods should leave out the reaction of anilins with the blood in cases of diabetes mellitus. That, as yet, the work may be open to criticism, we do not doubt; but every microscopical student interested in the subject might at least endeavor either to improve our knowledge, or to disprove the value of the test by systematic examinations.

We usually find the statement made that to detect the difference between diabetic and non-diabetic blood, owing to the amount of sugar present in each, it is necessary to examine a *large quantity* of blood. This renders the investigation unpleasant to both physician and patient; and any method by which a satisfactory result can be obtained through using only *a drop or two* of blood will be very gladly accepted. Originality is not claimed in the methods here given, but I urge the further investigation of a method which seems to promise good results with very little trouble, and it is for this reason I send the slides and brief notes.

In blood examination, let us review the points to be carefully observed:

(a) Cleanliness of instruments, slides, covers and apparatus.

(b) Purity of dyes, which must be obtained from a reliable dealer, and should be especially designated for the particular study in hand.

(c) The employment of watery solutions, which should be filtered, as mould is liable to occur.

Digitized by Google

(d) Even films and not too thick, except for the microscopic examination.

(e) Strictly following an author's method.

(f) Avoiding over-heating, either in degree or time.

(g) Preparation of control slides under exactly the same conditions.

In examining blood in cases of suspected diabetes, remember there is yet something indefinite in our knowledge regarding the pathologic conditions; this affection shares somewhat in the confusion incident to the study of kidney disease generally. Herein is a source of error, which may, perhaps, result in no reaction, even though the method and technique be faultless. It is unnecessary here to enter into a discussion of symptoms and nomenclature beyond stating that the factor of time (i. e. duration of the disease) is important in differentiating between glycosuria and true diabetes. The latter term applies only to that form in which the specific gravity is high, sugar excretion abundant, diuresis, thirst and other cardinal symptoms present. It is an interesting fact that not only does the blood react to anilins, but also the urine, showing that glucose decolorizes in a warm alkaline solution, in urinalysis. In making the blood test it is often an advantage to test the urine also. In fact, this must be done, unless the investigator is experienced in blood work, and I would suggest the phenylhydrazin test as modified by R. T. Williamson, from Hoffmann and Ultzmann's work. It is a simple test, the reagents can be easily kept in powder, a short time only is required to make the examination, and it is possible to leave the specimen and look for the crystals when convenient. Permanent specimens may then be made of the large, fine, sulphur-yellow needle crystals, by drying the deposit on a slide and mounting in canada balsam. A small amount even of albumen does not seem to invalidate the test, though it is best to remove all we can by filtering. The test does not show any crystals of phenylglucosazone in normal urine. It gives no reaction with uric acid, creatinin, hippuric acid, pyrocatechin, as gotten by Fehling's method. The objection has been raised

Digitized by Google

that the test is too sensitive for clinical work, and that if glycuronic acid be present, similar crystals are formed. This is the case, if Moritz's method is used, but not if Williamson's be carefully followed.

The blood shows the *color* to be slightly darker than is the case with normal blood. The *reaction* is alkaline, even if coma be present, and is best tested by the papers especially devised by Haycraft and Williamson. The *percentage of water* varies but is usually slightly diminished. The *specific gravity*, though variable, is mostly increased. The *number of red corpuscles* also varies, though usually the hemoglobin is greater than normal, which is a differentiating point between many chronic ailments and saccharine diabetes. The *leucocytes* show no definite change in their proportion, though Professor Limbeck says leucocytosis accompanying digestion is frequently so well-marked in severe cases as to be a distinguishing mark of diabetes.

To prepare films for examinations, any one of several methods may be used. Among the best are

(a) Cover-glass films,
(b) Slide-films, and
(c) Dr. Manson's modification of the latter.

(*a*) *Cover-films* are readily made by placing two square covers diagonally across one another with a drop of blood between, and slipping them apart to spread the blood.

Or a cover can, after a little practice, be passed lightly over a drop of blood in such a manner as to barely touch its surface and leave a film thinly spread.

(*b*) *Slide-films* may be prepared by spreading a drop which has been put about one-third from the end of the slide, using a second slide to spread the drop by pushing it over the latter like a plane.

Or, slides may be lightly drawn, one over the other, starting from the center or a little beyond; this method is not so satisfactory if the specimens are intended for microscopic examination, as the film is at the end of the slide and inconvenient to examine over the circular opening in the stage.

Digitized by Google

(*c*) *Dr. Patrick Manson's Method* is a modification of the slide-film described above. Its details are as follows: Prick the finger after thoroughly cleansing it, wipe off the first drop, using the next for films. Have ready some strips of smooth gutta-percha tissue, or the thinnest tissue paper, three-fourths of an inch wide and an inch and a half long. Apply one of these strips to the exuded blood, about midway, and at once place the charged strip, blood surface down, upon a well-cleaned glass slip, wait a second or two till the blood spreads out, then draw the gutta-percha or paper by the uncharged end along the glass. A very thin film of blood, with evenly disposed corpuscles, is secured, and at least three or four slips may be prepared from the one charging if neatly and quickly done. Let the slips dry, and they may be stained and examined at any later period that is convenient. The use of tissue paper is recommended, for the absorption of blood in the paper allows the spreading of a large number of films and retards coagulation longer than any other method. Personally I prefer a strip of stout note-paper held with the thumb and first two fingers so it curves part way around the index finger. The curved end is used to take up the blood, and then drawn lightly along the slide at an acute angle, leaving an even film with the corpuscles thinly and regularly distributed.

For the preservation of mounts of blood, especially if stained with methylen blue, iodine gum will be found useful, as the stained specimens fade so easily in the balsam; even such objects as the plasmodiae show nicely in the gum.

The films must now be *fixed*, which may be done by any one of the following methods:

(*a*) *Absolute Alcohol* for ten minutes.

(*b*) *Absolute Alcohol and Ether*, equal parts—the maximum time that allowed sharp staining I found to be twenty-five minutes.

(*c*) *Formol*, 10 per cent.

(*d*) *Bichloride of Mercury*, a method in which care must be used to avoid crystalline deposits, and not recommended for diabetic blood.

Digitized by Google

(*e*) *Heat* incubation or by Ehrlich's copper plate.

(f) Gulland's method, the formula being:

Saturated solution of eosin in absolute alcohol...25 c. c.
Pure ether..... .....25 c. c.
Sol. of mercury bichloride in abs. alc. (2 grms. in 10 c. c.).....5 drops or so.

The last method is useful as a time-saver, for the slides are dropped in the fluid while the films are wet, or if covers are used the films are quickly immersed in the solution before drying occurs, 5cc. to 10cc. being sufficient for four films. Three minutes are sufficient to fix the films, though immersion for twenty-four hours will not harm them. Wash in water very thoroughly and counterstain if desired. (Sputum and pus can also be stained and fixed by Gulland's method.)

To detect Glycogen in the Blood.—Prepare the films or slides, dry and mount in iodine gum, made as follows:

Iodine..... ....1 part
Potassic Iodide .....3 parts
Distilled Water, to which an excess of pure Gum Arabic has been added....100 parts.

Glycogen is detected in two forms. (1) In the multi-nuclear neutrophilic leucocytes, as intra-cellular glycogen. (2) As free extra-cellular glycogen, which arises from the degeneration of the leucocytes. *In normal blood* only the extra-cellular glycogen can be recognized with certainty by the action of iodine in cover preparations. But *in diabetic blood* minute specks of glycogen, stained deep brown with iodine can be seen distinctly in some leucocytes, and the amount of extra-cellular glycogen is two or three times more than in cover preparations of normal blood.

Ludwig Bremer gives a very simple test to distinguish diabetic from non-diabetic blood, by its action in decolorizing methylen blue. [*Methyl blue* is absolutely useless in this work; the pure "medicinal" or "Methylen blau nach Ehrlich" giving the best results. I understand Dr. Rotch advises Grübler's methylen blue, soluble in alcohol, as the best.] R. T. Williamson uses the same anilin-reaction in a different

Digitized by Google

manner. There are several modifications of Bremer's method, and for convenience we shall describe two, the *microscopic* and the *macroscopic*.

(*a*) *The Microscopic Method.*—Make thin even cover films of some diabetic and normal blood. Fix with equal parts of absolute alcohol and ether; it is recommended to place the fixative in a vessel over a water-bath and boil for four minutes. Then stain, in a specially prepared solution made as follows: Take saturated watery solutions of eosin and methylen blue; mix in equal parts. A precipitate forms, which should be filtered off, washed, dried and reduced to powder. A ½ part of eosin and ½ of methylen blue are added. From 0.025 grm. to 0.05 grm. of this mixture is dissolved in 10 grms. of a 33 per cent. solution of alcohol. Stain for four or five minutes in a warm place, wash in distilled water rapidly, dry in air and mount. The diabetic film, or glycosuric blood corpuscles are stained a sap or bluish-green. Non-diabetic blood is a reddish violet or madder color. Le Goff used a watery solution of eosin mixed with a saturated watery solution of methylen blue (proportions not given, but possibly equal parts); the resulting precipitate he washed and dried. Five grams of this substance he directs to be dissolved in twenty to twenty-five grams of alcohol (30 per cent.). Filter the solution. Covers are heated in an incubator for two hours at a temperature of 120° C., then stained with the above solution, washed in distilled water, dried with bibulous paper and mounted in xylol-balsam. The red corpuscles of normal blood stain variously from a clear purplish rose-color to a dark maroon, while diabetic red corpuscles stain pale green, yellowish-green, or are unstained. Nuclei of white cells are blue, and are the same in normal and in diabetic blood. He records some very interesting color-reactions of diabetic blood. Bremer prefers the blue to be free from zinc, while Lépine prefers zinc to be present. The former urges using a fresh solution, added to the water just before use. Lépine has described a similar reaction in leukaemia, but it is quite likely that glycosuria was also present.

Digitized by Google

A modification of Bremer's method is to use a 2 per cent. solution of methylen blue for two minutes, then stain for ten seconds in a 0.125 per cent. solution of eosin. Keeping all the precautions of Bremer in view it was found that in every case of diabetes in which the amount of sugar in the urine was more than 2 per cent. the blood gave the characteristic reaction. Even in a case where dieting had caused the sugar to disappear, the reaction persisted. No reaction is found in the blood of severe anaemia. The blood plasma is not essential in producing the reaction. If 5 ccm. of blood be taken from a vein of a diabetic patient and placed in a centrifuge, the corpuscles are readily separated from the plasma. The corpuscles, after being washed in normal saline solution until the washings give no trace of sugar, still give the Bremer reaction.

(*b*) *The Macroscopic method* also shows that the red blood corpuscles which stain normally with *acid* stains, in diabetes require *basic* dyes.—Smear evenly upon two slides, about ½ or ⅓ their length, a tolerably thick film of blood—normal blood on one slide and diabetic blood upon the other. Heat in an incubator six to ten minutes at a temperature of 135° C. [In a personal note, Dr. Bremer advises that the flame be removed when the temperature reaches 130° C., 135° C. being the optimum and 129° C. the lowest point at which the test is reliable. Heating for over ten minutes also renders the film valueless.] Now stain in a 1 per cent. aqueous solution of one or more of the stains on the following page.

The reaction is possibly due to the alkalinity, but as yet is imperfectly understood. Almost any histological stain will do to differentiate diabetic from normal blood, provided that according to its chemical constitution it has an affinity either for non-diabetic or diabetic red blood corpuscles.

The blood reaction obtained by methylen blue is of value in distinguishing the coma of diabetes from other forms of coma, especially in cases, seen for the first time, in which the patient without history or friends, is brought to the hospital in an unconscious condition. Where no urine can be obtained,

Digitized by Google

STAIN	METHOD	REACTION OF BLOOD	
		NORMAL	DIABETIC
(a) Congo-Red.	1 per cent. Aqueous Sol. for 1½ to 2 min. Wash in Dist. H_2O rapidly, dry.	Stained Red.	Not stained or only indifferently.
(b) Methylen Blue.	" "	" Greenish-Blue.	" "
(c) Biebrich Scarlet.		Unstained.	Deeply stained.
(d) Ehrlich-Biondi.	2—8 min. (1 per cent.)	Violet.	Orange.
——*BEAUTIFUL CONTRASTS BY*——			
Double Staining: Methyl Green.	1 per cent. Aqueous Sol. 1½ to 2 min. Wash in Dist. H_2O.		Green, deeper than in normal blood.
Double Staining: Eosin.	⅛-1 per cent. Aqueous Sol. 10 sec. Wash, dry.	Eosin Color.	Green.
Double Staining: Methylen Blue.		Red Corpuscles Deep Brown or Purple.	Red Corpuscles
Double Staining: Eosin.			Green or Greenish-Yellow.

Digitized by Google

the blood test furnishes an accurate and ready means of diagnosis.

Williamson's Modification.—Thoroughly clean a *narrow* test tube (a wide one gives too large an area for the action of oxygen), and place in it 40 ccm. of distilled water. With a Southall's 1 ccm. tube take 20 ccm. of blood from the finger and blow it gently into the water. Should it stick to the side, carefully shake it to the bottom. Then add 1 ccm. of a 1:6000 water solution of methylen blue, and then add 40 ccm. of a solution of potassium hydrate. Mix well by shaking. Also make a control specimen of normal blood. We see the fluid in each tube has a fairly deep blue color. Place them in a beaker and heat in a water-bath until the boiling point is reached. Boil four minutes. The diabetic blood is now changing from a deep blue to a dirty pale yellow, almost the color of normal urine. The normal blood remains blue, or bluish-green, sometimes a pale violet, but never decolorizes, i. e., never loses its blue color. N. B.—The tubes must be kept quite still in the water-bath, as shaking causes decolorization of methylen blue by oxidation from the atmosphere, and the blue may return. Severe cases will decolorize a methylen blue solution of double strength, i. e., 1:3000. No other disease, I believe, has yet been found that will decolorize the blue. The reaction is probably due to excess of grape-sugar, as this substance readily removes color from a warm alkaline solution of methylen blue as seen in the urine test.

In conclusion: Anilin methylen blue is also used for estimating the amount of sugar in the blood, and as a test for glucose in the urine. Safranin 1:1000 is also used, and others of the same group.

Possible failure to secure the reaction may result from neglect of the precautions enjoined, from use of impure dyes, from experiment on cases not truly diabetic, or from insufficient experience on the part of the worker. But to condemn a method without repeated tests by a sufficient number of competent observers is certainly wrong. The anilin reaction of blood in diabetes may in time prove as helpful as the Widal

Digitized by Google

reaction in typhoid fever, which, though not, as we all hoped it would be, a *sure and early positive diagnosis* in typhoid fever, is valuable as one determining factor in diagnosis. Even in these days of comparative uncertainty, a blood examination is essential to a modern practitioner's investigation of a supposed case of typhoid; and it may prove an equal, if not a better aid, in the study of diabetes.

808 Morse Ave., Chicago, Ill.

BIBLIOGRAPHY.

ALLEN.—Chemistry of Urine.
VON JAKSCH.—Clinical Diagnosis.
RIEDER.—Blood Atlas, &c.
LIMBECK.—Diseases of Blood, etc.
STENGEL.—Twentieth Century Medicine.
OSLER.—Pepper's American Text book of Medicine.
LOEWY.—British Medical Journal, Vol. 1, June, 1898.
COLES, A. C.—On Blood Diseases.
BREMER.—Centralblatt für Med., June 5, 1897.
———— N. Y. Med. Jour., Mar. 7, 1896.
———— Medical News, Philadelphia, Feb. 9, 1895.
———— British Med. Jour., July 3, Aug. 28, 1897.
LITER JET. LE GOFF.—Paris, 1897, p. 44.
LÉPINE ET LYONNET.—Lyon, Med., 1896, Vol. 82.
———— Lyon, Med., 1896–1897.
R. MAGUIRE.—Fowler's Dictionary of Medicine.
WILLIAMSON.—Centralblatt für Wiss. Med., Berlin, 1894.
HUTCHISON AND RAINY.—Clinical Diagnosis, 1888.
GULLAND.—British Med. Journal, March, 1897.

Digitized by Google

COMPARATIVE STUDY OF THE SOFT PALATE.

By WILLIAM FAIRFIELD MERCER, Ph. M.

WITH PLATES I AND II.

In the preparation for the observations given below sections were made of the soft palate of the cat, adult and fetal, the rat, the guinea-pig, the calf, and the puppy.

Most of the hardening was done in picric alcohol, sections cut in paraffin, 10μ thick, stained in hematoxylin, and counter-stained in picro-fuchsin.

In general the same tissues are found in all the palates studied, but with quite a range of distribution, no two of them having the same relative amount or position of the parts.

A section of the palate of the puppy is represented in Figure 1. The epithelium of this palate, as of all of them, is of two kinds, squamous and columnar, and extends over the entire surface of the organ. The squamous epithelium is of the typical form and extends over the entire oral surface, around the free end, upon the nasal surface to a point marked x, Figure 1, where it is gradually replaced, in a manner to be described later, by the columnar epithelium which extends over the remaining surface of the organ.

Under the epithelium, closely connected with it, is a layer of connective tissue. This extends quite generally throughout the organ and surrounds masses of glands. These glands are of the typical mucous form (Fig. 8). In the puppy, which is the one now under consideration, these glands open upon both surfaces by the means of ducts (Fig. 1, *Gd*). The glands in this particular palate are arranged upon the two sides of a central mass of striated muscle (Fig. 1, *M*) which extends the

Digitized by Google

entire length. It seems to be the general rule for the glands to be arranged so that the opening is to the side opposite a band of muscles. If the muscle is through the middle they open upon both surfaces, if at one sidet he ducts extend to the opposite surface.

Blood vessels, nerves, and lymphoid tissue are quite generally distributed throughout the organ.

A section of the soft palate of the rat is represented in Figure 2. In this the squamous epithelium extends farther if anything upon the nasal surface as at x, Figure 2. The connective tissue is arranged similarly to that in the palate of the puppy, but the layer of muscles (*M*) is entirely at the nasal side and the glands are all at the oral side of the palate, and therefore open into the mouth and not into the nasal cavity. As seen in the figure the glands are in a continuous mass. In this palate the muscles have more of a varied direction, for there are some trans-sections of muscle as well as longi-sections in the same specimen. Blood vessels are quite prominent.

Figure 3 represents a longi-section of the palate of the guinea-pig. The first thing that attracts one's attention to the palate of the guinea-pig is the way it is arranged in the throat of the animal. The palate extends in a continuous curtain backward and downward and joins with the tongue at the sides, so the only opening into the pharynx is a small hole in the middle line, not larger than a fair sized lead pencil. In cutting through the center, the appearance in Figure 3 is given. A section of a piece of the tongue (*T*) is shown in relative position.

In this palate the ciliated epithelium (*Ce*) extends to the point x on the nasal surface.

The connective tissue is about equally distributed upon both sides of the glandular tissue (*Mg*) which is not found, or very little at most, near the free end of the palate. This free end has, in the place of the glandular tissue, more muscles. In this, as in the palate of the rat, the glands are all at the one side of the layer of muscle and their ducts (*Gd*) invariably open

Digitized by Google

upon the oral surface. Lymphoid tissue (*L*) is rather more abundant than in the rat and less so than in the puppy.

The section of the palate of the calf (Fig. 4) shows a massive organ, but with quite general characteristics as compared with those of the puppy; having epithelium of the same kind and extent, and muscles extending through the center with the glands (*Mg*) upon either side sending their ducts (*Gd*) to both surfaces.

The direction of the muscles differs greatly from that of the puppy. In this, the sections being cut in the same general plane, the muscles are cut in various directions, while in the puppy they are cut in perfect longi-section. The distribution of gland substance is somewhat different from any of the palates described, viz., that small masses are found distributed at varying intervals throughout the connective tissue (*C*) as well as large masses bordering upon the muscles.

Figure 5 represents a longi-section of the palate of the adult cat. In this the shape first attracts attention, being thick at the fixed end while comparatively thin at the free margin. The thickened portion contains large masses of glandular tissue while the thinner portion contains very little. The glandular tissue has quite a well marked division, indicated by C^1, which throws it into two groups. The ducts (*Gd*) from these divisions open upon their respective surfaces. So in the cat, ducts open upon both the nasal and oral surfaces. In the free end of the palate is found a mass of glandular tissue mixed with lymphoid tissue. Ciliated epithelium extends down the nasal surface to *x*. The muscles appear in longi-section in the free end, in the thickened portion in cross or oblique sections.

Figure 6 shows a section of the palate of the rabbit. In this, while the epithelium and connective tissue are about as in the others in extent and quantity, the glands are in great excess, extending throughout the organ to the very tip. The muscles are all bunched at the nasal side, thereby throwing the glands to the other (the oral) with all their openings upon that surface. In the section described the muscles are cut in various direc-

Digitized by Google

tions. In the thicker portion of the section there is found a band of connective tissue (C^1) which is quite characteristic of this palate. This separates the glands from the muscles. Lymphoid tissue (L) is more abundant in this palate than in any other described.

Figure 8 shows a section of the mucous gland with a duct. The characteristic mucous cell (mg) is found. The cells extend to the lumen of an acinus, A^1 in cross section and A in longi-section, with the nucleus at the outer margin. Blood vessels are distributed throughout the tissue, held in place by fibers of connective tissue. The gland duct (Gd) is made up of a coat of connective tissue lined by a layer of epithelial cells (Fig. 9, E) which is continuous with the epithelium of the surface. Figure 9 shows the portion of Figure 8 indicated by the arrow, under the 1-12 oil immersion lens.

Figure 7 represents a section of the palate of the fetal kitten. This has no glands as such; but in their place a mass of cells with large nuclei. In some places the razor has passed through these cells in the plane of the long axis of the mass. In these sometimes a lumen is noticed but no mucous cells, as are found in the adult, or even in the new born kitten. By tracing a mass of these cells through a series of sections the cells are found to be continuous with the epithelium of the surface and of the same kind. In this the ciliated epithelium extends around the free end of the palate from the nasal surface to the oral surface, to a point x quite a distance from the apex. It is evident that these cells are ciliated until the organ is put to use, when the ciliated epithelium is replaced by squamous epithelium.

In the place of connective tissue and muscle as such, the structure is more a mixture of both, connective tissue fibers with elongated nuclei between them, with now and then a few muscle fibers, not very distinct.

Of the soft palates studied three had ducts opening upon both surfaces, that of the cat, the puppy, and the calf. Three had ducts opening upon one surface only, viz., the guinea-pig, the rabbit, and the rat. Invariably, if the ducts open upon one

Digitized by Google

surface only it is upon the oral. So the nasal surface must receive its mucous from other sources than itself. The relative arrangement of the other tissues of the organ is determined by the location of the glands with respect to the muscles.

This investigation also brings out the fact that the cells of the columnar epithelium extend to the basement membrane instead of being stratified as formerly described. Cells of varying form, from round to quite elongated, are found among the long tapering portions of the ciliated cell (Fig. 10, *Ce*). This figure is taken at the point of transition of the two forms of epithelium. It is to be noticed that at the point of transition between the ciliated and the squamous epithelium the cells of the squamous epithelium (*Se*) are overlaid with the cells of the columnar epithelium, that the cells of the columnar epithelium become shorter, and the cilia less and shorter as they push out over the squamous epithelium. The bases of the cells rest upon the layer of connective tissue (*C*) described in other parts of the paper.

Cornell University, Department of Histology and Embryology.

Digitized by Google

PLATE I.

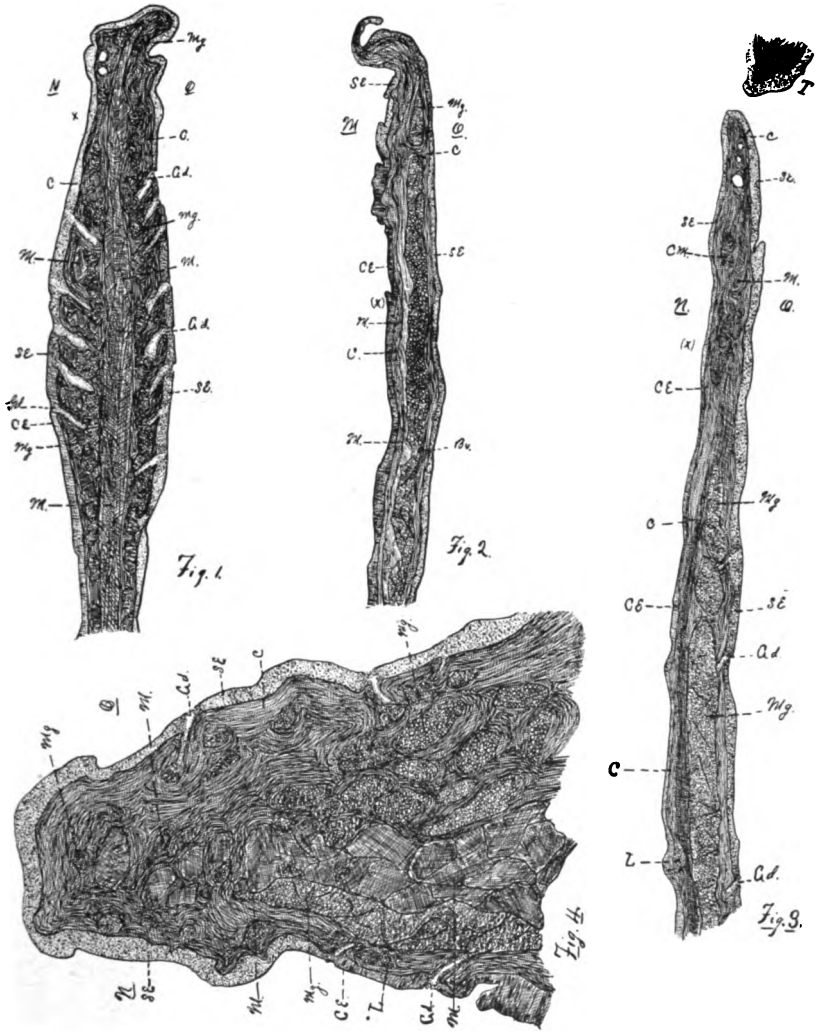
Fig. 1. Longi-section of palate of puppy.
Fig. 2. Longi-section of palate of rat.
Fig. 3. Longi-section of palate of guinea-pig.
Fig. 4. Longi-section of palate of calf.

List of Abbreviations used in Figures.

A. Lumen of acinus, longi-section.
A^1. Lumen of acinus, cross section.
Bv. Blood vessel.
C. Connective tissue.
C^1. Connective tissue between muscle and glands.
Ce. Columnar epithelium.
E. Epithelium lining gland ducts.
Gd. Section of gland duct.
L. Lymphoid tissue.
Lm. Lymphoid tissue with glandular tissue.
M. Muscle, striated.
Mg. Mucous glands.
N. Nasal side.
O. Oral side.
Se. Squamous epithelium.
x. Point of division between squamous and columnar epithelium.

Digitized by Google

PLATE I



Digitized by Google

Digitized by Google

Digitized by Google

PLATE II.

Fig. 5. Longi-section of palate of adult cat.

Fig. 6. Longi-section of palate of rabbit.

Fig. 7. Longi-section of palate of fetal kitten.

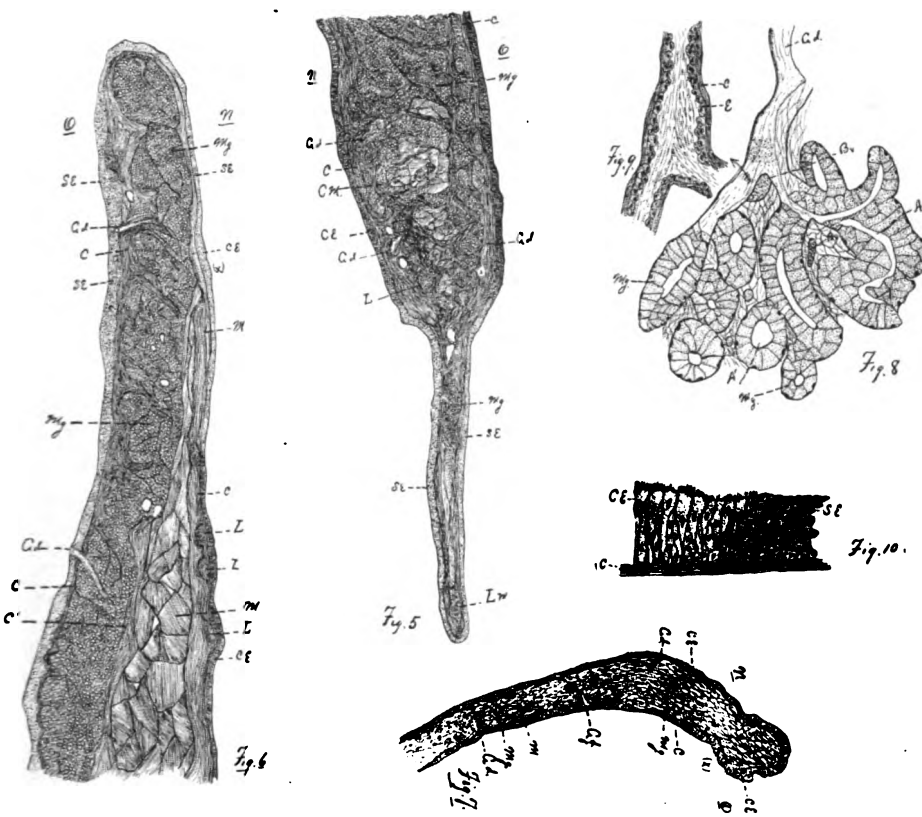
Fig. 8. Section of mucous gland under high power, taken from palate of rabbit.

Fig. 9. Section of gland duct, at point indicated by the arrow in Fig. 8, under very high power.

Fig. 10. Section of epithelium through point of transition from squamous to columnar epithelium.

Digitized by Google

PLATE II



Digitized by Google

Digitized by Google

THE EYES OF THE BLIND VERTEBRATES OF NORTH AMERICA, II. THE EYES OF *TYPHLOMOLGE RATHBUNI* STEJNEGER.*

By CARL H. EIGENMANN.

WITH PLATES III AND IV.

The caves of North America are inhabited by three salamanders whose eyes range in their structure from the perfectly normal to the most degenerate known among the Batrachia.

Spelerpes maculicauda (Cope) is common in the caves of the Mississippi Valley. As far as I have been able to determine, its eyes have not undergone any degeneration. (Fig. 10.) It is abundant and so nearly allied to *Spelerpes longicauda* Green, an epigean species of very wide distribution, that it has until recently been considered identical with it.

Typhlotriton spelæus Stejneger, is restricted to the western caves of the Mississippi Valley. It has so far been found in Marble Cave and Rockhouse Cave, and smaller caves in the same neighborhood in southwestern Missouri. It is found under rocks in and out of the water. This is the most interesting form inasmuch as it is a much more typical cave animal than *Spelerpes*, but has not yet reached the degenerate condition of *Typhlomolge*. Its eyes are apparently normal in the larva, but in the adult have undergone marked degeneration. (Fig. 11.) The eye-lids are disappearing, and the rods and cones are no longer present in the adult. The eyes of this species will be dealt with in another place.

Typhlomolge rathbuni Stejneger, is found in the underground streams near San Marcos, Texas. It has been secured from the

* Contributions from the Zoological Laboratory of the Indiana University, No. 29.

Digitized by Google

artesian well at San Marcos, and from a surface well. It has also been noticed in one of the caves near that place, Ezel's, in which the underground water can be reached. It is said to have come out of some artesian wells south of San Antonio. It is a perennibranch and spends all of its time in the water. Its remarkably long and slender legs are unable to support its body when out of the water. Its eyes form the basis of the present paper. (Fig. 12.)

In February, 1896, the first recorded specimens of this species were cast up from an artesian well about 190 feet deep, bored by the U. S. Fish Commission. Other specimens have since been thrown up at the rate of thirty to fifty a year.

The U. S. Fish Commission, through Dr. B. W. Evermann, sent me four specimens of this salamander and a number of its eggs. The late Prof. W. Norman, of the University of Texas, and Prof. Wm. Bray, of the same place, secured me an additional number. To all of these gentlemen I wish to acknowledge my appreciation and indebtedness.*

The specimens received from the U. S. Fish Commission through Prof. Evermann are as follows:

One adult, received in Washington Apr. 8, 1896.

Three young, of different sizes, received Mar. 11, 1896.

A few eggs laid about Mar. 15, 1896.

The specimens sent me by Prof. Evermann were preserved in alcohol; those sent by Prof. Norman had been killed in Perenyi's fluid. The sections were stained chiefly in Biondi-Ehrlich's tricolor mixture. While the present account contains all that my material warrants me to say concerning these eyes, I appreciate that very much more is left to be done by some one who has access to an unlimited supply of living material of this interesting animal.

---

* More recently I visited the caves and artesian well at San Marcos, and have been able to observe the living specimens. On this visit I was put under endless obligations to the very efficient Superintendent of the U. S. Fish Hatchery at San Marcos, Mr. J. L. Leary. My notes on the living salamander, together with Prof. Norman's observations, will be published elsewhere.

Digitized by Google

The following gives the dimensions of the eyes in a number of individuals. Professor Norman sent only the heads, so I am able to give only approximately the length of those specimens sent by him. The approximate sizes were obtained by comparing the distance between the eyes with the same distance in entire specimens.

		Left Eye		Right Eye	
Length of specimen	Distance between eyes	Longitudinal diameter	Transverse diameter	Longitudinal diameter	Transverse diameter
30 mm.	1.44 mm.	.336 mm.	.232 mm.	.368 mm.	.240 mm.
About 47 mm.	1.92 mm.	.432 mm.	.320 mm.	.432 mm.	.304 mm.
About 70 mm.	3.10 mm.	.544 mm.	.384 mm.	.608 mm.	.368 mm.
.....	.....	.496 mm.	.432 mm.	.544 mm.	.384 mm.
About 90 mm.	4.00 mm.	.592 mm.	.400 mm.	.592 mm.	.448 mm.

The eye of *Typhlotriton* is, in many respects, much more degenerate than that of its European caverniculous relative, *Proteus*. In *Proteus* the six muscles are all present; in *Typhlotriton* they have entirely disappeared. In the former all the layers normal to the retina are present; in the latter the conditions are much simpler. In *Proteus* the lens is still present, and blood-vessels still enter the eye; in *Typhlotriton* no trace of the lens could be found, except in one individual, and blood-vessels no longer enter the eye. While some of the asymmetry may have been caused by reagents, it is evident that there is a great deal of fluctuation in the shape of the eye. The eye is irregular-oval in outline as seen from above, but the optic nerve enters it at the posterior half of its inner face. The eye also increases materially in size from the smallest to the largest of the specimens examined, and this increase is not directly proportional to the increase in the length of the animal, so the young have relatively larger eyes. (Pl. II, fig. 1.)

The eye lies immediately beneath the skin, to which it is attached by a connective tissue mass which is horizontally elongate. The axis of the eye makes an acute angle with the surface of the skin, the eye being directed outward and forward. The dermis over the eye does not differ from that in the neighboring tissues. The epidermis, in the largest individual, is perceptibly thinner over the eye, i. e., from the continuation of

Digitized by Google

the axis of the eye to the surface of the epidermis. The measurement, in the largest individual, of the epidermis at a point over the eye and 320μ above and below this point gives the following:

Thickness over the eye 73μ, 320μ above the middle of the eye 96μ, 320μ down from the eye 80μ.

The same elements are found over the eye that are evident in other regions. There is no indication of a past free orbital rim; the dermis and epidermis are directly continuous over the eye. There are no eye muscles and no glandular structures connected with the eye. It is surrounded on all sides, except where it becomes associated with the skin, by loose connective tissue meshes, filled with fatty tissue, and is bound to the dermis by many fibres running in various directions, and among these a few pigment cells are found.

SCLERA AND CHOROID.

(a) Largest specimens. Cartilaginous elements are found in the sclera of but two eyes. In one individual 90 mm. long, the left eye possesses a cartilage, while there is none in the right eye. It is in this case placed just above the entrance of the optic nerve, and measures 96μ in thickness, 160μ vertically, and 204μ antero-posteriorly. In all other cases it is a thin, flocculent layer not distinctly separable from the layers beneath it. It is thickest about the entrance of the optic nerve. Over the front of the eye there are a few denser strands which may represent the remains of the cornea. Over the sides of the eye of the largest individual the sclera measures from 4μ to nothing. About the entrance of the optic nerve it attains a thickness of 14μ, and contains here many flat nuclei with a length up to 17μ.

The choroid reaches a thickness of 20μ near the entrance of the optic nerve, and dwindles regularly from this point to the distal face of the eye. Blood-vessels are found in it next to the pigmented epithelium of the eye. Otherwise it is a mass of pigment interlarded with streaks of colorless tissue containing nuclei. Over the front of the eye, next to the epithelium, there are a number of colorless cells with large, granular nuclei.

Digitized by Google

(b) Essentially the same conditions exist in younger specimens, but the parts are relatively thinner.

The ophthalmic artery, which extends approximately parallel with the optic nerve during its distal course, is sometimes surrounded by pigment. (Figs. 2 and 3.)

THE PIGMENT LAYER, EXCLUSIVE OF THE IRIDEAL PARTS.

The pigment layer is a thin, compact layer, densely pigmented. In an individual 30 mm. long it is about 8μ in thickness. As there are no rods and cones, the inner surface of this layer is similar to the outer, that is, the cells form a pavement epithelium. In places, however, processes of the cells extend in among the cells of the nuclear layers, for a distance of 40μ in some cases (Fig. 2), to the inner reticular layer. In the individuals 70 to 90 mm. long, the pigment epithelium reaches 16μ in thickness.

The only indication of a lens was found in the eye of a specimen 72 mm. long. In this a small lenticular group of cells lay in the opening of the pupil. It measured 24x40μ. (Fig. 9.)

THE IRIS AND ORA SERRATA.

Marked changes take place between the smallest and largest individual examined, so that these must be dealt with seriatim.

(a) The smallest individual 30 mm. long. (Figs. 4 and 5.)

On the left side the pupil measures 22μ in diameter; the distance from the margin of the pupil to the ora serrata measures approximately 100μ. The epithelial portion of this iris consists of an outer layer of dense pigment considerably (14μ) thicker than the pigment epithelium of the rest of the eye. At the pupil this pigment appears rolled into the inner surface of the iris, where it is continuous with the inner layer of cells, which consists of a layer of ordinary pigmentless epithelium 6μ thick, with the nuclei elongate and placed obliquely, and 24μ in length. A few of these ordinarily pigmentless cells show pigment. There is a distinct thickening of the iris at the margin of the pupil. The pigment cells lying on the inner face of this region are much less densely pigmented than those of the

Digitized by Google

outer layer, and their nuclei are quite evident. The pupil is closed with colorless cells belonging to the choroid. (Fig. 6.)

In the specimen 70 mm. long, very marked changes have been brought about. The pupil was 24μ wide on the right, but is now an oblique channel, and the lower margin of the iris overlaps the upper margin. On the left it is more nearly as in the younger stages, but wider (48μ). The free margin of the iris reaches now the enormous thickness of 56 to 80μ. The pigmented epithelium has rolled in more so that the elongated nuclei, free from pigment, are crowded together in the region of the ora serrata. The pupil is filled in part with pigment, evidently of choroidal origin. (Fig. 7.)

The right eye of the specimen 90 mm. long. The choroidal pigment has forced its way into the interior of the eye, and forms a conical-shaped mass like a plug in the iris, and extending into the depth of the vitreous cavity. Apparently on the external half of the iris the pigmented layer has become rolled in and folded upon itself in the interior of the eye, giving rise to a pigment mass over 100μ thick. No such mass is present in the left eye. The pigment on the inner or upper half of the iris is as in the younger stages.

The choroidal pigment entering the eye is in solid, vermiform strands.

THE RETINA.

The retina of *Typhlotriton* is much simpler than that of *Proteus*. In the latter all the layers typical of the perfect retina are still distinguishable (Kohl '92, p. 88). In the former the outer reticular layer has entirely disappeared, and the layers between the rods and cones and the inner reticular layer form a mass of cells that are homogeneous as far as ordinary histological methods permit one to determine. There are nowhere the slightest evidences of any rods or cones either in the largest or smallest individual. The nuclei of the outer nuclear, the horizontal and inner nuclear layers are alike. Müllerian fiber-nuclei have not been distinguished as such. This layer consists of about five series of nuclei, and measures 44μ in thickness in

Digitized by Google

the smallest (30 mm.), and 48μ in the largest (90 mm.) specimen; it is between 32 and 48μ in the specimen 70 mm. long.

The inner reticular layer is thin, but well defined. It is 6μ thick in the smallest specimen, 16μ in the specimen 70 mm. long. In section the ganglionic layer forms a U-shaped mass of cells. In the larger specimens it is about 60μ thick, and made up of from five to seven series of cells. The vitreous cavity is a widely flaring, trumpet-shaped structure, with its pointed end reaching about the center of the eye. In the older specimens it is filled by fibers and cellular tissue, apparently continuous with the choroid ingrowth from the pupil. (Fig. 8.)

The optic nerve is 17μ in diameter in the 30 mm. specimen. In the largest specimen it is 24μ thick without its sheaths. At its passage through the pigmented layer of the retina it is contracted to a width of but 14μ. Within this layer it expands to 28μ. After passing directly through the ganglionic layer it is distributed to the cells of this layer, some of the fibers being bent at an acute angle to reach the cells near the entrance of the nerve into this layer. A large number of isolated pigment granules are found associated with the nuclei of the optic nerve within the eye from its entrance to the ganglionic layer. (Fig. 6.) There is no sheath of pigment such as is found in *Typhlogobius*. Pigment cells are also occasionally present in the very center of the eye (Fig. 6), and are presumably associated with the optic nerve. The sheath of the optic nerve consists of a direct continuation of the choroid layer, which is for a shorter distance pigmented, and of a continuation of the sclera.

Blood-vessels do not enter the eye with the nerve, and none were with certainty detected, except in the largest individual, where they are closely associated with the choroidal mass of tissue that has grown into the eye through the pupil.

SUMMARY.

1. The eye lies just beneath the skin. The skin is but little thinner over the eye than elsewhere, and shows no structural characters different from those of neighboring regions.

2. The eye muscles have vanished.

3. The lens has vanished, and its place has in part become filled by an ingrowth of choroidal tissue containing pigment.

Digitized by Google

4. The vitreal body is very small, if present at all. The vitreal cavity is a funnel or trumpet-shaped space.

5. The pigmented layer of the retina is a pavement epithelium with indistinct cell boundaries, and with occasional pigmented processes extending into or through the nuclear layers.

6. Rods and cones are not formed.

7. The outer reticular layer has disappeared.

8. The inner and outer nuclear layers form one layer, cells indistinguishable from each other.

9. The inner reticular layer, as usually with degenerate eyes, is relatively well developed.

10. The ganglionic layer is well represented and connected with the brain by the well developed optic nerve.

11. The epithelial portion of the iris is at first simple, with an outer pigmented and an inner colorless layer. With age the margins of the iris become folded inward in such a way that the pigmented layer may be thrown into folds in the interior of the eye, while the colorless layer is but little affected.

12. Pigment granules, and rarely pigmented cells, are associated in the eye with the optic nerve.

13. The eye is more degenerate than that of the European *Proteus*. It is less degenerate than that of the North American blind fishes *Amblyopsis*, *Typhlichthys*, and *Troglichthys*, but much more so than that of the species of *Chologaster*.

PAPERS EXAMINED.

EIGENMANN, C. H., '99: The Eyes of the Amblyopsidæ. Archiv f. Entwickelungsmechanik VIII, pp. 543-615.

KOHL, C., '92 and '93; Rudimentäre Wirbelthieraugen. Bibliotheca Zoologica. Heft 18 und 14.

STEJNEGER, LEONHARD, '92; Preliminary Description of a New Genus and Species of Blind Cave Salamanders from North America. Proc. U. S. Nat. Mus., XV., pp. 115-117.

———————, '96. Description of a New Genus and Species of Blind Tailed Batrachians from the Subterranean Waters of Texas. Proc. U. S. Nat. Mus., XVIII., pp. 619-621.

Digitized by Google

Digitized by Google

PLATE III.

DESCRIPTION OF FIGURES.

All figures except those from photographs have been drawn with the aid of the camera lucida.

1. Pigment epithelium.

3-7. Outer nulear to inner reticular layers of the normal retina.

8. Inner reticular layer.

9. Ganglionic layer.

chr. Choroid.

cps. Blood corpuscles.

i^1. Outer layer of the iris, epithelial.

i^2. Inner layer of the iris.

n. op. Optic uerve.

p. Pupillary margins.

scl. Sclera.

z. Pigment cells which have entered the eye.

Fig. 1. Outline sketch of part of the section of the head of a specimen 90 mm. long, showing the position of the eye.

Fig. 2. Right eye of a specimen 80 mm. long.

Fig. 3. Exit of the optic nerve of the same.

Fig. 4. Iris of the left eye of the same specimen.

Fig. 5. Upper half of iris of the right eye of a specimen 70 mm. long.

Fig. 6. Right eye of a specimen 70 mm. long.

Fig. 7. Right eye of a specimen 90 mm. long.

Fig. 8. Exit of optic nerve of the same eye.

Fig. 9. Lens of a specimen 72 mm. long.

Digitized by Google

PLATE III

Digitized by Google

Digitized by Google

Digitized by Google

PLATE IV.

DESCRIPTION OF FIGURES.

Figs. 10-12. The heads of the three cave salamanders of North America. The heads were subjected to the same treatment to prepare them for photography, and the photographs were taken under approximately the same magnification.

Fig. 10. The head of a *Spelerpes maculicauda* 54 mm. long. × 14.

Fig. 11. The head of a *Typhlotriton spelæus* 54 mm. long. × 15.

Fig. 12. The head of a *Typhlomolge rathbuni* 47½ mm. long. × 14

Digitized by Google

PLATE IV

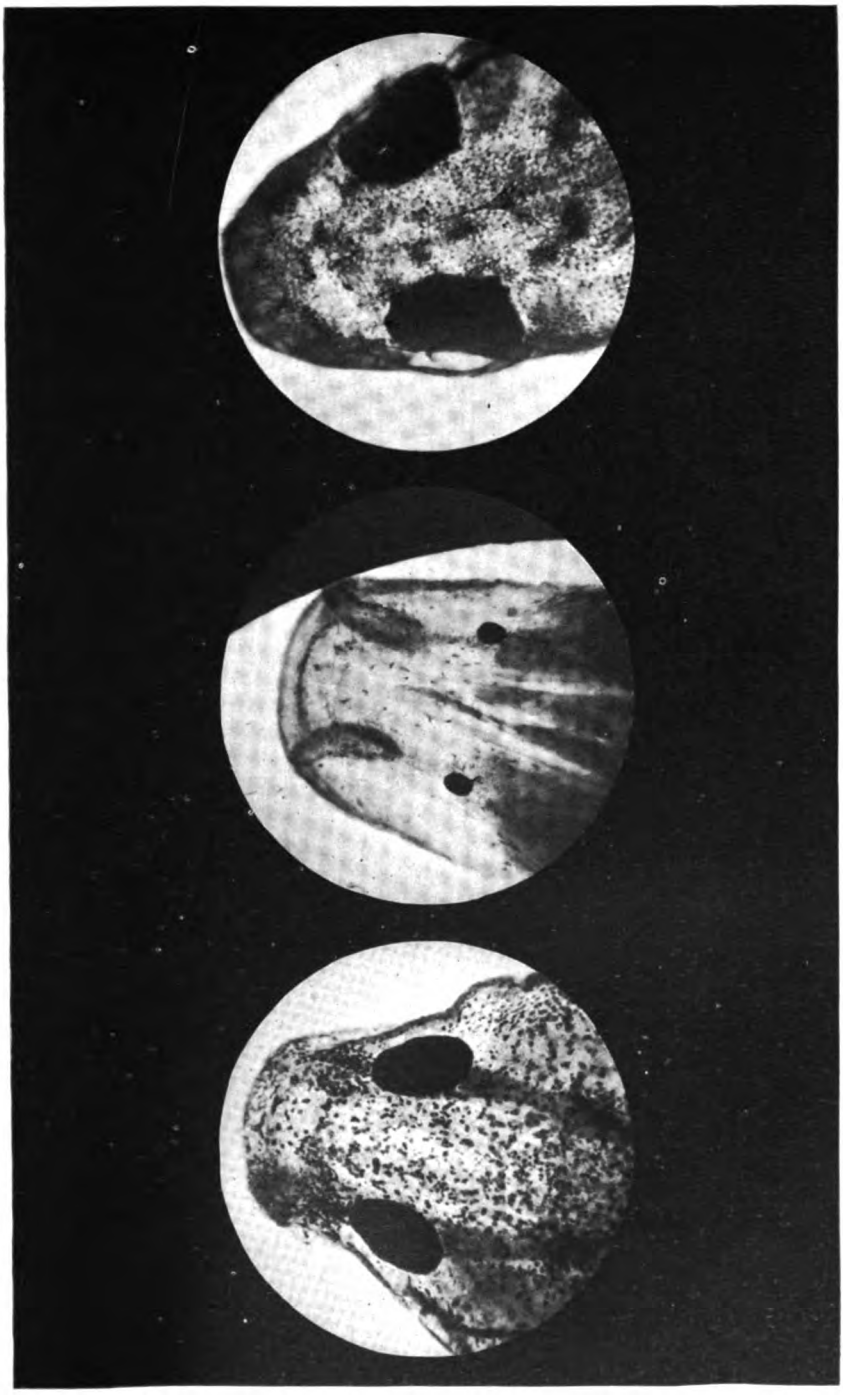


Figure 10 at top; 11 at bottom; 12 between.

Digitized by Google

Digitized by Google

THE MODERN CONCEPTION OF THE STRUCTURE AND CLASSIFICATION OF DIATOMS.

WITH A REVISION OF THE TRIBES AND A REARRANGEMENT OF THE NORTH AMERICAN GENERA.

By CHARLES E. BESSEY, Ph. D.

WITH PLATE V.

In the revision of the Bacillariaceae for Engler and Prantl's "Pflanzenfamilien," Schütt has availed himself principally of the studies of Otto Müller and has given us the first clear conception of the meaning of the diatom cell, and its relation to the diatom filament. Starting with the filament, we regard it as the typical condition, from which the unicellular diatoms have been derived by the solution of the filament and the adaptation of the separate cells to an independent life. Diatoms are thus regarded as typically filamentous algae, and are no longer to be placed among unicellular plants. Accordingly their place in the system is readily determined, and there is no longer any excuse for trying to assign them to the Protophyta or Phaeophyceae, much less to place them outside the vegetable kingdom. Schütt asserts their near relationship to the Desmidiaceae, and Engler in his "Syllabus der Pflanzenfamilien" assigns them to the Euphyceae, with Desmidiaceae and Zygnemaceae as close relatives on the one hand, and the Peridiniales on the other.

In a recent study of the diatoms in the light of these views as to their structure, I have accepted Schütt's interpretation with a slight modification, and have adopted the principal fea-

Digitized by Google

tures of his classification, introducing, however, some changes in both, which I fear he may not accept. What follows must then be understood as based upon Schütt's monograph, but with my own modifications so freely introduced that the responsibility for the views set forth must rest with the present writer rather than the eminent German monographer.

FAMILY BACILLARIACEAE.

Cells yellowish-brown (by the addition of phycoxanthin to the chlorophyll) in unbranched filaments, circular, angled or flattened in cross section (end view or valve view); or more commonly separated early into isolated individuals (sometimes, however, more or less associated together in gelatinous colonies) which are similarly shaped, or variously twisted or bent; cell wall at first composed of cellulose, early more or less completely silicified, in most tribes very finely porous, and often wholly or partly covered with a gelatinous layer; the walls of each cell constitute a closed box ("frustule" of older authors), consisting of two ends ("valves") and two overlapping rings, the "girdle," and in many cases of "interzones" (zwischenbänder), which lie between the girdle and the valves; the interzones are sometimes mere rings, but often they have more or less complete septa which transversely divide the cavity of the cell; chromatophores one or two, large and lamelliform, or numerous, small and granular; propagation (1) by the division of the cell (always at right angles to the axis of the filament) forming two similar cells, (2) by the escape of the protoplasm from its wall, its rapid growth into a larger cell and the formation of an entirely new wall (rejuvenescence), and (3) by contraction of the protoplasm of a cell and the formation of a new thick and armed wall (asexual resting spore); generation by the union of the escaped protoplasmic contents of the two cells, resulting in the formation of one or two new, usually much larger cells (several modifications of this process have been observed). Minute fresh water and marine plants, floating free or attached to various objects.

Digitized by Google

The family is readily separated into two sub-families:

A. Sub-Family Centricae.—Cells in transection circular, less commonly polygonal or elliptical, and rarely irregular; valves marked concentrically or radially by dots, areolations, lines or ribs; cells often with spines, processes or horns.

B. Sub-Family Pennatae.—Cells in transection narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate or irregular; valves marked pinnately or transversely by dots, areolations, lines or ribs; cells without spines, processes or horns (spines very rarely present, e. g., *Dimerogramma* and *Cymatosira*).

Under the sub-family Centricae are arranged nine tribes, the sequence being from those which are typically cylindrical filaments to those which are flattened filaments, in the former more commonly remaining as filaments, in the latter more commonly separating into individual cells. (Plate V.)

Under the sub-family Pennatae are arranged six tribes, the sequence being from those typically filamentous to those typically separated into individual cells. (Plate V.)

In further interpretation of the diatom structure as indicating the relationship of these two sub-families I have regarded them as constituting two separate but somewhat parallel genetic lines, in which the Coscinodisceae and Fragilarieae are approximately primitive, the former having given rise to the Centricae and the latter to the Pennatae.

In comparing the two sub-families it is interesting to note that the species of Centricae are largely marine and fossil, and those of Pennatae are largely fresh-water and recent. The structure of the plants of the former is relatively simpler, but the superficial ornamentation is usually more marked, while in the Pennatae the structure is increasingly more complex up to the Naviculeae, Bacillarieae and Surirelleae, where the raphe is a characteristic structure, while in these the superficial ornamentation is less marked.

I may say in passing that I have a similar conception of the structure of the Desmids, and that in the arrangement of the

Digitized by Google

families of the Conjugatae I regard the Zygnemaceae as more nearly primitive, with their filamentous, unbranched plant-body, and that the Desmids and Diatoms represent two similar and somewhat parallel genetic lines, in which the filaments tend to break up early into independent cells, the former with a less modified cell wall, the latter with its wall usually much modified by the deposition of silica.

KEY TO THE TRIBES.

A. SUB-FAMILY CENTRICAE.—Cells in transection circular, less commonly polygonal or elliptical, and rarely irregular; valves marked concentrically or radially by dots, areolations, lines or ribs; cells often with spines, processes or horns.

I. Cells short box-shaped or discoid, mostly circular in transection, usually without horns or projections,

a. Valves not divided into sectors by ribs, sometimes with radial rows of dots, without "eyes" (round or oval, definitely bounded, hyaline areas) or nipples, Tribe 1. *Coscinodisceae.*

b. Valves divided into sectors by ribs, without "eyes" or nipples, Tribe 2. *Actinodisceae.*

c. Valves with radial undulations, or dome-shaped projections, the latter with "eyes," nipples or spines, Tribe 3. *Eupodisceae.*

II. Cells two to many times as long as broad, circular, rarely round-elliptical in transection; girdle with numerous interzones, Tribe 4. *Solenieae.*

III. Cells box-shaped, about as long as broad (rarely much longer), transection circular to elliptical, with two to many horns much longer than the cell; interzones rarely present, Tribe 5. *Chaetocereae.*

IV. Cells box-shaped, shorter than broad or but little longer, transection circular, polygonal or commonly elliptical; valves with two (rarely one) to more poles, each pole with a projection or horn which is shorter

Digitized by Google

than the cell, or when about its length provided with claws; interzones rarely present,

Tribe 6. *Biddulphieae.*

V. Cells box-shaped, as long as broad or shorter, elliptical, sometimes lunate in transection; valves without horns or projections; rarely with interzones,

a. Valves lunate, without transverse septa,

Tribe 7. *Euodieae.*

b. Valves not lunate,

1. Valves with transverse septa, without spines,

Tribe 8. *Anauleae.*

2. Valves without transverse septa, with a marginal row of spines, Tribe 9. *Rutilarieae.*

B. Sub-Family Pennatae.—Cells in transection narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate or irregular; valves marked pinnately or transversely by dots, areolations, lines or ribs; cells without spines, processes or horns (spines very rarely present, e. g., *Dimerogramma* and *Cymatosira*).

I. Rachis of the valves (i. e., the line between the divergent pinnate markings) evident as a narrow unmarked strip (pseudoraphe), rarely wanting; valve without a slit (raphe),

a. Cells usually little shorter than broad or longer, with numerous interzones, mostly united into filaments,

Tribe 10. *Tabellarieae.*

b. Cells prevailingly much shorter than broad ("rod-shaped" of older authors, the longer axis of the rod representing one of the transverse axes of the cell), often united into filaments,

1. Cells cuneate in girdle view (i. e., valves not parallel), rachis median, interzones present,

Tribe 11. *Meridioneae.*

2. Cells rectangular in girdle view, or if cuneate the rachis not median, interzones present or absent,

Tribe 12. *Fragilarieae.*

Digitized by Google

II. Rachis containing an elongated slit (raphe) through the cell wall,

a. Rachis commonly median, often more or less lateral, not keeled or when keeled not punctate, interzones present or absent, Tribe 13. *Naviculeae.*

b. Rachis lateral, less often median, punctate-keeled, raphe not plainly visible, Tribe 14. *Bacillarieae.*

III. Rachis evident as a narrow, unmarked strip, or keeled; valve with two lateral wing-keels, each enclosing a raphe, Tribe 15. *Surirelleae.*

A. SUB-FAMILY CENTRICAE.

Tribe I. Coscinodisceae.

Key to the Genera.

I. Cells forming filaments, girdle side marked,

a. Valves without spines,

1. Entire valve uniformly marked, 1. *Lysigonium.*

2. Margin and center of valve differently marked,

a. Marginal portion a narrow ring, 2. *Paralia.*

b. Marginal portion a very broad radially striate ring,

1. Central portion finely punctate, 3. *Hyalodiscus.*

2. Central portion areolated, 4. *Hyalodictya.*

b. Each valve with a circle of spines, 5. *Stephanopyxis.*

II. Cells single, girdle side not marked,

a. Long box-shaped, central portion of valves coarsely areolated, 6. *Craspedodiscus.*

b. Cells disk-shaped,

1. Valve markings not consisting of sinuate lines,

a. Valve with distinct central and marginal portions, without spines, 7. *Cyclotella.*

b. Central and marginal portions of valve grading into one another,

1. Valve with a circle of spines, 8. *Stephanodiscus.*

2. Valve without spines, 9. *Coscinodiscus.*

2. Valve markings consisting of sinuate lines, 10. *Liradiscus.*

Digitized by Google

1. *Lysigonium* Link (*Melosira* Agardh). Cells cylindrical (or elliptical), closely joined together, not carinate, sometimes transversely furrowed, sometimes superficially denticulate in the plane of the fracture, valves simply punctate. Species numerous, in fresh and marine waters.

2. *Paralia* Heiberg. Cells cylindrical, valves furrowed parallel to the edge, valve markings of two kinds, at the center finely punctate, at the edge a circle of areolae. Species few, marine and fossil.

3. *Hyalodiscus* Ehrenberg. Cells solitary, geminate or several, valves orbicular, with radiating lines, and with a distinct central smooth umbilicus. Species few, marine and fossil.

4. *Hyalodictya* Ehrenberg. Like the preceding, but with the umbilicus closely areolate. Species one, in fresh waters.

5. *Stephanopyxis* Ehrenberg. Cells cylindrical or discoid (occasionally elliptical in transection), mostly united in chains, valves tumid convex, hexagonally alveolate, spines usually coronal, sometimes wanting. Species many, marine and fossil.

6. *Craspedodiscus* Ehrenberg. Cells solitary, long box-shaped, valves diversely areolate, central portion sharply defined from the surrounding border by a spiny line. Species few, marine and fossil.

7. *Cyclotella* Kützing. Cells mostly single or in twos, short cylindrical, discoid, valves saucer-shaped, diversely marked, central portion inflated, smooth or granulate, surrounded by a circular border marked by fine radiating lines. Species numerous, mostly in fresh waters.

8. *Stephanodiscus* Ehrenberg. Cells single, short cylindrical, discoid, valves circular, slightly convex, not hexagonally areolate, radially granulate with hyaline spaces between the radii, center hyaline or granulate, edge with a simple crown of spines. Species many, mostly in fresh waters, some fossil.

9. *Coscinodiscus* Ehrenberg. Cells single, discoid, valves circular, rarely elliptical or rhomboid, flat or centrally depressed, sometimes undulate or plicate, often with a central hyaline circular or irregular area, which may contain an areolate rosette;

Digitized by Google

markings areolate or granulate, margin narrow or broad, mostly with marginal spines. Species very many, marine and fossil.

10. *Liradiscus* Greville. Cells single, discoid, with a narrow girdle band, valves circular to elliptical, somewhat convex, flattened towards the edge, surface sinuate-reticulate, more or less rough, sometimes with small spines, no central area, margin narrow and hyaline, or broad and radially lined. Species few, marine and fossil.

Tribe II. Actinodiscear.

Key to the Genera.

I. Ribs or sectors without claws,
  a. No sharp separation of central and marginal portions,
    1. Radial ribs not transversely connected, 11. *Stictodiscus.*
    2. Radial ribs connected by transverse lines or rows of granules, 12. *Hemiptychus.*
  b. Center areolated and surrounded by a hollow, radially chambered border, 13. *Planktoniella.*

II. Ribs or sectors with claws,
  a. Valve radially undulate, the alternate sectors dissimilar, 14. *Actinoptychus.*
  b. Valve not undulate,
    1. Rays all alike, 15. *Asterolampra.*
    2. One of the rays dissimilar, 16. *Asteromphalus.*

11. *Stictodiscus* Greville. Cells single, discoid, valves circular or angled, more or less convex (often unequal), with radial ribs usually not reaching to the center, central area usually granulate. Species many, mostly marine and fossil.

12. *Hemiptychus* Ehrenberg (*Arachnoidiscus* Ehrenberg). Cells single, discoid, valves circular, with numerous stout radiating ribs (often alternately longer and shorter), which are connected by transverse lines or rows of granules, center hyaline. Species few, marine and fossil.

13. *Planktoniella* Schütt. Cells single, discoid, flat; valves circular, consisting of a sharply defined, slightly areolated center,

Digitized by Google

surrounded by a broad, hyaline, hollow, radially chambered and ribbed border. Species one, marine.

14. *Actinoptychus* Ehrenberg. Cells single, discoid, valves circular to hexagonal, with radial more or less dissimilar undulations, the surface mostly hexagonally areolate; sectors provided with marginal claws; umbilicus central, often hyaline and mostly stellate. Species many, marine and fossil.

15. *Asterolampra* Ehrenberg. Cells single, discoid, flat; valves circular or obtusely angled, with similar hyaline, radial rays, all reaching the margin and there provided with marginal claws; center sometimes areolate, margins always areolate, with a middle non-areolated band between the marginal band and the center. Species many, marine and fossil.

16. *Asteromphalus* Ehrenberg. Cells single, discoid; valves circular or elliptical to oval, with sub-similar, hyaline, radiating rays, all reaching the margin and there provided with marginal claws; center hyaline, crossed by radial zigzag lines, and surrounded by a broad areolated field divided by the rays. Species many, marine and fossil.

Tribe III. Eupodiscear.

Key to the Genera.

I. Valves with nipples, no "eyes," 17. *Tripodiscus.*

II. Valves without nipples, with "eyes,"

a. "Eyes" sub-marginal, small,

1. Valve surface granulate in radiating lines, one "eye," 18. *Actinocyclus.*

2. Valve surface mostly areolate, one to four "eyes," 19. *Eupodiscus.*

b. "Eyes" not marginal, usually large, 20. *Auliscus.*

17. *Tripodiscus* Ehrenberg (*Aulacodiscus* Ehrenberg). Cells single, discoid or box-shaped; valves circular (rarely polygonal), bearing one to forty-five sub-marginal nipple-like processes, flat, crateriform, or with an elevated zone; markings granular, in straight or crooked lines. Species many, marine and fossil.

Digitized by Google

18. *Actinocyclus* Ehrenberg. Cells single, discoid, or short box-shaped; valves circular to elliptical or rounded rhomboid, flat (rarely convex), granulate, the granules usually round, and arranged radially; central area usually round; one round, sub-marginal "eye." Species many, marine and fossil.

19. *Eupodiscus* Ehrenberg. Cells single, discoid; valves circular, flat or slightly convex, center often depressed; markings mostly areolate, without a central area, "eyes" one to four, small, near the margin; spines small, few to many, sub-marginal. Species few, marine and fossil.

20. *Auliscus* Ehrenberg. Cells single, discoid; valves circular, round to elliptical (rarely bluntly angled), flat, with usually two (rarely one, three or four) truncate, conical processes, each terminating in a large "eye;" central area usually present; markings of the surface variable, granulate, pruinate, to areolate. Species many, marine and fossil.

Tribe IV. Solenieae.

[We have but one genus.]

21. *Rhizosolenia* Ehrenberg. Cells long cylindrical, forming chains; girdle composed of numerous scale-like, almost ringed segments; valves unsymmetrical, oblique to the long axis of the cell; cell-wall but little silicified. Species many, mostly marine, rarely in fresh waters.

Tribe V. Chaetocereae.

Key to the Genera.

I. Valves circular, with many horns, 22. *Bacteriastrum*.

II. Valves elliptical, each with two horns, 23. *Chaetoceros*.

22. *Bacteriastrum* Shadbolt. Cells short cylindrical, usually shorter than broad, forming chains, with numerous horns arising at the margins of the valves. Species few, marine.

23. *Chaetoceros* Ehrenberg. Cells short elliptical, shorter or longer than broad, forming chains; valves elliptical, each bearing two long horns, girdle bands but little silicified. Species many, marine.

Digitized by Google

Tribe VI. Biddulphieae.

Key to the Genera.

I. Projections or horns without claws,
  a. Valves alike,
    1. Valves tri- to multipolar, with a projection at each angle,
      a. Strongly silicified, without spines or claws, 24. *Triceratium.*
      b. Weakly silicified, a stout spine at each pole, 25. *Lithodesmium.*
    2. Valves bipolar,
      a. With spines, strongly silicified,
        1. Projections strongly developed, 26. *Biddulphia.*
        2. Projections reduced, each bearing a slender spine, 27. *Zygoceros.*
      b. Without spines, weakly silicified, 28. *Eucampia.*
  b. Valves unlike, 29. *Isthmia.*
II. Projections or claws with terminal claws, 30. *Hemiaulus.*

24. *Triceratium* Ehrenberg. Cells prismatic, box-shaped, free or connected in chains; valves three to many angled, angles more or less prolonged into protuberances, without spines or claws. Species many, nearly all marine and fossil.

25. *Lithodesmium* Ehrenberg. Cells prismatic, box-shaped, united into long chains; valves three angled, each angle with a stout terminal spine; girdle band of many scale-like segments; cell walls incompletely silicified. Species few, marine and fossil.

26. *Biddulphia* Gray. Cells box-shaped, elliptical to subcircular in transection, free or connected in chains; valves usually strongly convex, bipolar, each pole with a short protuberance or stout horn, which is rounded or truncate; valves frequently with stout spines. Species many, marine and fossil.

27. *Zygoceros* Ehrenberg. Like *Biddulphia*, but with the protuberances of the valves reduced, and bearing a slender spine-like or thread-like horn. Species few, marine and fossil.

Digitized by Google

28. *Eucampia* Ehrenberg. Cells short, slightly curved, forming spiral chains; valves elliptical, flat or with two protuberances; girdle band mostly with many cross-lines; cell walls weakly silicified. Species few, marine and fossil.

29. *Isthmia* Agardh. Cells box-shaped, mostly longer than thick, and broad, trapezoidal, free or united into tree-like colonies; valves elliptical, dissimilar, each with a protuberance; girdle band distinct. Species few, marine and fossil.

30. *Hemiaulus* Ehrenberg. Cells mostly box-shaped, transection elliptical to multiangular, with relatively long protuberances, united into chains; valves bi- to multipolar, each pole extended into a short or long horn, terminating in one or more claws. Species many, marine and fossil.

Tribe VII. Euodieae.

[We have but one genus.]

31. *Hemidiscus* Wallich (*Euodia* Bailey). Cells box-shaped, single; valves lunate, markings areolate or granulate. Species few, marine and fossil.

Tribe VIII. Anauleae.

Key to the Genera.

I. Valves with transverse septa appearing in girdle view as straight, incomplete partitions,
   a. Valves straight, 32. *Anaulus.*
   b. Valves slightly curved, 33. *Eunotogramma.*

II. Valves with transverse septa appearing in girdle view as bent, incomplete partitions,
   a. Incomplete partitions bent-capitate, 34. *Terpsinoe.*
   b. Incomplete partitions, after bending, elongated parallel to the valve-face, 35. *Porpeia.*

32. *Anaulus* Ehrenberg. Cells box-shaped, single; valves elliptical, straight, with two transverse septa, which appear as straight, short, incomplete partitions in the girdle view; valve markings punctate. Species few, marine and fossil.

33. *Eunotogramma* Weisse. Cells as in *Anaulus*, but the valves slightly curved, and with two to many transverse septa. Species few, marine and fossil.

Digitized by Google

34. *Terpsinoe* Ehrenberg. Cells box-shaped, single or united into chains by their angles or valve-faces; valves symmetrical, oblong-elliptical, with lateral undulations, and with two to many transverse septa which in girdle view appear as short, incomplete partitions with thickened curved ends (resembling "notes" of written music). Species few, fresh-water, marine and fossil.

35. *Porpeia* Bailey. Cells box-shaped, single; valves oblong-elliptical, the middle and ends swollen, with two transverse septa which in girdle view appear as incomplete partitions, which soon bend axially parallel to the valve-face. Species few, marine and fossil.

Tribe IX. Rutilarieae.

[We have but one genus.]

36. *Rutilaria* Greville. Cells much broader than long, in valve view oblong-elliptical, united into short chains; valves boat-shaped, somewhat elevated at the ends, surrounded by tooth-like spines. Species few, marine and fossil.

B. SUB-FAMILY PENNATAE.

Tribe X. Tabellarieae.

Key to the Genera.

I. Transverse ribs of the valves, when present, not extending into the cell cavity,

a. Valves with a few prominent transverse ribs, 37 *Tetracyclus.*

b. Valves transversely striate only,

1. Interzones two to many, septa not undulate,

a. Valves coarsely striate, pseudoraphe present, 38. *Rhabdonema.*

b. Valves finely striate, pseudoraphe absent, 39. *Striatella.*

2. Interzones two, septa undulate, 40. *Grammatophora.*

II. Transverse ribs of the valves extending deeply into the cell cavity, 41. *Denticula.*

Digitized by Google

37. *Tetracyclus* Ralfs. Cells united into flat filaments, shorter or longer than broad, with many interzones, and centrally perforated transverse septa; valves elliptical to oblong, swollen in the middle, without prominent median line, no nodules, and sparingly transverse ribbed. Species few, fresh-water and fossil.

38. *Rhabdonema* Kützing. Cells united into flat filaments, shorter or longer than broad, the filaments basally attached by a gelatinous cushion on one corner of the end cell; interzones many, externally cross-marked, their transverse septa variously perforated; valves elliptical or linear-lanceolate, with a pseudoraphe, and transverse-beaded lines and no nodules. Species few, marine and fossil.

39. *Striatella* Agardh (*Tabellaria* Ehrenberg). Cells shorter or longer than broad, united into flat filaments which may partly separate into zigzag chains, basally attached by one corner; interzones few to many, each with an alternately perforated septum; valves linear to elliptical-oblong, more or less swollen centrally and at the ends; without pseudoraphe or nodules; surface transversely striate, not ribbed. Species many, fresh-water, marine and fossil.

40. *Grammatophora* Ehrenberg. Cells shorter than broad, united into flat, zigzag chains, basally attached; interzones two, each with an undulate, centrally perforated transverse septum; valves linear to elliptical, sometimes swollen in the middle and sometimes at the ends also, with a faint pseudoraphe, and polar but no central nodules, mostly finely cross striate. Species many, marine and fossil.

41. *Denticula* Kützing. Cells free, single or united into very short, flat filaments; interzones two, each with a transverse septum with a row of perforations; valves lanceolate, without raphe, with transverse ribs and striae. Species few, fresh-water, brackish water, and fossil.

Digitized by Google

Tribe XI. Meridioneae.

Key to the Genera.

I. Valves punctate or variously punctate-striate, without transverse ribs,
  a. Not stalked, 42. *Sceptroneis*.
  b. Cells stalked,
    1. Each interzone with a septum only at its broader end, 43. *Licmophora*.
    2. Each interzone with a scalariform-fenestrate septum, 44. *Climacosphenia*.

II. Valves finely transverse-striate and with transverse ribs, 45. *Meridion*.

42. *Sceptroneis* Ehrenberg. Cells free, mostly single, cuneate in valve and girdle view; interzones wanting; valves transversely moniliform-striate, with pseudoraphe which is sometimes very broad; polar nodules sometimes recognizable. Species few, fresh-water, marine and fossil.

43. *Licmophora* Agardh. Cells stalked, single or forming fan-like chains, cuneate in valve and girdle view; interzones two, open at the narrower end and with a septum at the broader end; valves very finely transversely striate, and with a pseudoraphe; nodules wanting. Species many, marine.

44. *Climacosphenia* Ehrenberg. Like *Licmophora*, but the interzones with scalariform-fenestrate septa. Species few, marine and fossil.

45. *Meridion* Agardh. Cells free, united into fan-shaped or spiral chains, cuneate in valve and girdle view; interzones wanting; valves cuneate, rounded at the ends, with transverse ribs, and fine, transverse, centrally interrupted striae, this interruption forming a pseudoraphe. Species few, in fresh waters.

Tribe XII. Fragilarieae.

Key to the Genera.

I. Rachis median,
  a. Valves with transverse ribs, or if not ribbed, with a central "eye,"

Digitized by Google

1. Without a central "eye," 46. *Odontidium.*
2. With a central "eye," 47. *Plagiogramma.*

b. Valves without transverse ribs, without a central "eye,"

1. Ends of valves alike,

a. Cells in filaments, or zigzag chains,

1. Valves flat, without polar nodules, 48. *Fragilaria.*

2. Valves raised at the ends, and often in the middle, with polar nodules. 49. *Dimerogramma.*

b. Cells single, or forming fan-like, stalked clusters, 50. *Synedra.*

2. Ends of valves unequally swollen, 51. *Asterionella.*

II. Rachis near one margin,

a. Ends of valves alike,

1. Pseudoraphe and central nodule evident, 52. *Ceratoneis.*

2. Pseudoraphe and central nodule not evident, 53. *Eunotia.*

b. Ends of valves unlike, 54. *Tibiella.*

46. *Odontidium* Kützing (*Diatoma* DC.). Cells united into short bands or zigzag chains, which are attached at the base, not cuneate, girdle view oblong-rectangular; valves lanceolate to linear with transverse ribs, and fine transverse striae, the latter interrupted centrally by the indistinct pseudoraphe; no central nodule. Species few, in fresh waters.

47. *Plagiogramma* Greville. Cells often united into chains, free, not cuneate, girdle view oblong-rectangular; valves linear or elliptical, transversely punctate striate and sometimes ribbed, with a central "eye;" pseudoraphe often present; terminal nodule present. Species many, marine and fossil.

48. *Fragilaria* Lyngby. Cells united into mostly ribbon-shaped, rarely zigzag, chains, not cuneate, girdle view rectangular, mostly narrowly linear; valves linear-lanceolate or fusiform, flat, transversely striate or with transverse rib-like, beaded markings but no true ribs; pseudoraphe present; no nodules. Species many, fresh-water, marine and fossil.

Digitized by Google

49. *Dimerogramma* Ralfs. Cells united into ribbon-like chains, not cuneate, girdle view rectangular; valves lanceolate to linear-lanceolate, sometimes broader or narrower in the middle, not flat, raised at the ends, and often in the middle, with coarse or fine transverse-punctate striations, interrupted by the pseudoraphe; with polar and often central nodules. Species few, marine and fossil.

50. *Synedra* Ehrenberg. Cells free or attached, single or in fan-shaped clusters, not cuneate, girdle view linear; valves linear or lanceolate-linear, sometimes somewhat crinkled, transversely striate, mostly with a pseudoraphe; sometimes with false central and polar nodules. Species many, fresh-water, marine and fossil.

51. *Asterionella* Hassall. Cells attached into a star-shaped cluster, not cuneate, girdle view narrowly linear, with unequally thickened ends; valves narrowly linear with unequally swollen ends, very finely transverse striate, with a pseudoraphe; no nodules. Species few, fresh-water and marine.

52. *Ceratoneis* Ehrenberg. Cells free, single, not cuneate, girdle view linear; valves crescentic, faintly or not at all transversely striate; pseudoraphe present close to the concave edge; polar and central nodules present. Species few, fresh-water and fossil.

53. *Eunotia* Ehrenberg. Cells free or united into chains, or attached, not cuneate, girdle view rectangular-oblong; valves crescentic, often undulate on the convex margin, transverse striae uninterrupted; pseudoraphe not evident; polar nodules present; central nodule wanting. Species many, fresh-water and fossil.

54. *Tibiella* Bessey (*Actinella* Lewis*). Cells attached into fan-shaped colonies, cuneate in girdle view; valves curved, with the ends unequally swollen, finely transverse-punctate-striate, with marginal beads or spines; pseudoraphe indistinct; polar

* ***Actinella*** Lewis (1865) is antedated by ***Actinella*** Persoon (1807), as well as by ***Actinella*** Nuttall (1818), and must therefore be suppressed. The name ***Tibiella*** is suggested by the resemblance of the cells in valve view to the human tibia.

Digitized by Google

nodules present; central nodule wanting. Species few, fresh-water and fossil.

Tribe XIII. Naviculeae.

Key to the Genera.

I. Valves parallel,
  a. Rachis of valves not keeled,
    1. Raphe almost straight,
      a. Raphe with a simple border,
        1. Septa of interzones (when present) not fenestrate,
          †. Cells straight in girdle view, 55. *Navicula*.
          ††. Cells curved,
            §. Both valves with a raphe, 56. *Rhoiconeis*.
            §§. Only one valve with a raphe, 57. *Achnanthes*.
        2. Septa of interzones fenestrated,
          †. Both valves with a raphe, 58. *Mastogloia*.
          ††. Only one valve with a raphe,
            §. Interzonal septa narrow, marginal, fenestrated, 59. *Cocconeis*.
            §§. Interzonal septa complete, fenestrated, 60. *Campyloneis*.
      b. Raphe bordered by two ridges,
        1. Central nodule small or only slightly elongated, 61. *Brebissonia*.
        2. Central nodule much elongated, rib-like, 62. *Amphipleura*.
    2. Raphe strongly sigmoid or arcuate,
      a. Raphe sigmoid,
        1. Cell not twisted, 63. *Gyrosigma*.
        2. Cell twisted, 64. *Scoliopleura*.
      b. Raphe arcuate, 65. *Toxonidea*.
  b. Rachis of valves with a keel,
    1. Keel (including the raphe) sigmoid, median, 66. *Amphiprora*.
    2. Keel (including the raphe) arcuate, excentric, 67. *Amphitrite*.

Digitized by Google

II. Valves not parallel, ends approximating,
  a. Cells straight in girdle view, 68. *Gomphonema.*
  b. Cells curved in girdle view, 69. *Rhoicosphenia.*
III. Valves not parallel, edges approximating,
  a. Valves without transverse ribs,
    1. Girdle narrow, not striate, 70. *Cymbella.*
    2. Girdle broad, striate, 71. *Amphora.*
  b. Valves with transverse ribs, raphe not evident, 72. *Cystopleura.*

55. *Navicula* Bory. Cells single, free or enclosed in gelatinous tubes, or rarely united in chains, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; with or without interzones, interzonal septa not marginally chambered; valves bilaterally symmetrical, with a straight raphe (or nearly so), no keel, and round polar and central nodules, the latter sometimes elongated (stauros); surface transversely punctate-striate or ribbed. Species very many, fresh-water, marine and fossil.

56. *Rhoiconeis* Grunow. Cells single, free, not cuneate, curved in girdle view, interzones several; valves elliptical-lanceolate, symmetrical, with a straight median raphe and central and terminal nodules; surface transversely striate. Species few, fresh-water, marine and fossil.

57. *Achnanthes* Bory. Cells single or forming short chains attached by the basal cell, cells curved only in girdle view; valves elliptical to lanceolate, often narrower or broader in the middle; valves dissimilar, the one concave with a true raphe and central and polar nodules, the other convex with a pseudo-raphe, both striate with transverse rows of dots, sometimes ribbed. Species many, fresh-water, marine and fossil.

58. *Mastogloia* Thwaites. Cells mostly enclosed in a gelatinous mass, not cuneate, lanceolate in valve view, and oblong in girdle view; valves like those of *Navicula*; two interzones present, each having a septum with a central opening surrounded by a row of rectangular chambers. Species many, fresh-water and marine.

Digitized by Google

59. *Cocconeis* Ehrenberg. Cells single, free, straight or curved in girdle view, and the plane of the upper valve with its margins curved downwards; valves round-elliptical to circular, dissimilar, the lower concave with a true raphe and nodules, the upper with a pseudoraphe and without nodules, both transversely punctate-striate; interzone one with a narrow marginal fenestrated septum, or none. Species many, fresh-water, marine and fossil.

60. *Campyloneis* Grunow. Cells single, free, curved in girdle view, and the plane of the upper valve with the margins curved downwards; valves scutelliform, dissimilar, the lower concave, transversely punctate-striate, with a straight raphe and central nodules, the upper convex, cribrose-punctate, with a pseudoraphe and without nodules; interzone one, between the lower valve and the girdle, its septum complete, fenestrated. Species few, marine and fossil.

61. *Brebissonia* Grunow. Cells single, free or enclosed in gelatinous tubes, or sometimes stalked, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; without interzones; valves bilaterally symmetrical, with a straight raphe (or nearly so) which is enclosed between two parallel ridges; central nodule small, usually slightly elongated; surface transversely punctate-striate or ribbed. Species few, fresh-water and marine.

62. *Amphipleura* Kützing. Cells single, free, or enclosed in gelatinous masses or tubes, not cuneate, narrowly lanceolate in valve view, narrowly oblong in girdle view; valves bilaterally symmetrical; raphe straight, bordered by two parallel ridges, and separated by the long, narrow, longitudinal, rib-like central nodule; polar nodules small; surface transversely striate. Species many, fresh-water, marine, and fossil.

63. *Gyrosigma* Hassall (*Pleurosigma* W. Smith). Cells single, free or rarely enclosed in gelatinous tubes, not cuneate, straight and oblong-elliptical in girdle view, sigmoid in valve view; valves bilaterally symmetrical, sigmoid-lanceolate; raphe median, sigmoid; central nodule small; striations crossed, ob-

Digitized by Google

liquely (decussate) or at right angles (rectangular), reaching almost to the raphe. Species many, mostly marine, some in fresh waters, also fossil.

64. *Scoliopleura* Grunow. Cells single, free, twisted, not cuneate, girdle view oblong, the girdle oblique; valves elliptical, strongly convex, the raphe sigmoid, excentric; central nodule small; surface transversely striate, sometimes obliquely striate-pearled. Species few, fresh water, marine, and fossil.

65. *Toxonidea* Donkin. Cells single, free, not cuneate, twisted, lunate or arcuate in valve view, the girdle oblique; valves unsymmetrical, with an arcuate excentric raphe, and central and polar nodules; striations decussate. Species few, marine.

66. *Amphiprora* Ehrenberg. Cells single, free, not cuneate, twisted, lanceolate in valve view and oblong in girdle view but with a sigmoid girdle; interzones present; valves convex, with the raphe concealed in a sigmoid emarginate keel; central and polar nodules present; valves transversely striate, rarely scattered punctate. Species few, fresh water and marine.

67. *Amphitrite* Cleve (*Auricula* Castracane). Cells single, free, not cuneate, quite unsymmetrical; valves reniform, with an arcuate, emarginate, oblique keel at the convex margin including the raphe, central and polar nodules present; interzones present; striations of valves transverse or irregular. Species few, marine.

68. *Gomphonema* Agardh. Cells single, mostly stalked or in gelatinous masses, cuneate in both girdle and valve views; interzones present; valves bilaterally symmetrical, often laterally twice indented; raphe straight, with central and polar nodules, the former sometimes transversely elongated (stauros); surface transversely punctate-striate. Species many, fresh water, marine, and fossil.

69. *Rhoicosphenia* Grunow. Cells mostly stalked, cuneate in both girdle and valve views, curved in girdle view; interzones present; valves straight, bilaterally symmetrical, transversely striate, unlike; the concave valve with raphe and central

Digitized by Google

and polar nodules, the other without nodules, and with a pseudoraphe. Species few, fresh water and marine.

70. *Cymbella* Agardh. Cells single, stalked, (often becoming free) or enclosed in gelatinous tubes, oblong and straight in girdle view; no interzones; valves lunate, not symmetrical; raphe somewhat excentric, arcuate, rarely straight; central and polar nodules present; surface transversely striate, without ribs. Species many, fresh and brackish waters, and fossil.

71. *Amphora* Ehrenberg. Cells single, mostly free, elliptical to rectangular in girdle view; sometimes with cuneate interzones; valves lunate, not symmetrical; raphe excentric, near the concave margin, doubly arcuate; central nodule rounded or transversely elongated; surface transversely punctate-striate. Species very many, fresh water, marine, and fossil.

72. *Cystopleura* Brebisson (*Epithemia* Brebisson). Cells single, rarely in short chains, attached ventrally to other plants, girdle view oblong to doliiform; interzones present or absent; valves lunate, internally transversely ribbed, transversely beaded externally; raphe excentric near the concave margin (by some considered to be a pseudoraphe). Species many, fresh and brackish waters.

Tribe XIV. Bacillarieae.

Key to the Genera.

I. Keel median, 73. *Bacillaria*.
II. Keel at one edge, 74. *Homoeocladia*.

73. *Bacillaria* Gmelin. Cells parallel, in free chains, gliding upon one another in the chains, rod-shaped, straight, rhombic in cross section; valves linear, pointed, with a median, beaded keel in which is concealed the raphe; transversely striate. Species few, fresh water and marine.

74. *Homoeocladia* Agardh (*Nitzschia* Hassall). Cells mostly free, rarely in tubes or chains, sometimes stalked, elongated or linear, rarely cuneate, rhombic in cross section; valves linear to lanceolate, pointed, with the oblique, bordered keel at one edge enclosing the raphe; surface punctate or transversely or decussately striate. Species many, fresh water, marine, and fossil.

Digitized by Google

Tribe XV. Surirellear.

Key to the Genera.

I. Valve surface undulate, 75. *Sphinctocystis.*

II. Valve surface not undulate,

a. Valves cuneate, reniform, elliptical or linear, 76. *Surirella.*

b. Valves sub-circular, saddle-shaped, 77. *Campylodiscus.*

75. *Sphinctocystis* Hassall (*Cymatopleura* W. Smith). Cells free, oblong to linear, straight; valve surface undulate and transversely striate, with a beaded keel on each margin, containing the raphe; along the center of the valve extends a straight pseudoraphe. Species few, in fresh and brackish waters.

76. *Surirella* Turpin. Cells free or stalked, straight or twisted, in valve view cuneate, reniform elliptical or linear, girdle view cuneate, elliptical, oblong or sigmoid; valves with a beaded or ribbed keel on each margin containing the raphe; surface with ribs extending from the margin towards or to the median linear or lanceolate pseudoraphe. Species many, fresh water and marine.

77. *Campylodiscus* Ehrenberg. Cells solitary, free, disk-shaped, disk twisted or saddle-shaped, round elliptic; valves round elliptic, with short mostly radiate ribs, and a marginal keel concealing the raphe; pseudoraphe median, but at right angles in the two valves. Species many, mostly marine, a few in fresh waters.

Digitized by Google

PLATE V.

EXPLANATION OF PLATE.*

The family Bacillariaceae consists of two quite sharply separated sub-families, which probably originated by divergent development from a common ancestral filamentous type.

SUB-FAMILY CENTRICAE.

TRIBE I. COSCINODISCEAE, represented by *Stephanopyxis*, a short filament in girdle view, and one cell in valve view; *Coscinodiscus*, in valve view; *Lysigonium*, a short filament in girdle view, and a cell in valve view.

TRIBE II. ACTINODISCEAE, represented by *Stictodiscus*, in girdle view (above) and valve view (below); *Asteromphalus* in valve view; *Asteroptychus*, in girdle and valve views.

TRIBE III. EUPODISCEAE, represented by *Eupodiscus*, valve view (fragment); *Actinocyclus*, valve view; *Tripodiscus*, girdle view; *Auliscus*, valve (fragment) and girdle views.

TRIBE IV. SOLENIEAE, represented by *Corethron*, one cell in girdle view; *Lauderia*, a short filament in girdle view; *Rhizosolenia*, one cell and part of a second, in girdle view.

TRIBE V. CHAETOCEREAE, represented by *Bacteriastrum*, a short filament in girdle view; *Chaetoceros*, a filament in girdle view, and another in end (valve) view.

TRIBE VI. BIDDULPHIEAE, represented by a filament of *Eucampia*, a chain of *Triceratium* in both valve and girdle views, and cells and chains of *Isthmia* in girdle view, one above in valve view.

TRIBE VII. EUODIEAE, represented by fragments of *Hemidiscus* in girdle view, with a smaller fragment in valve view at the left.

TRIBE VIII. ANAULEAE, represented by *Terpsinoe*, in girdle and valve views, and *Anaulus* in two girdle views, and valve view (at the right).

TRIBE IX. RUTILARIEAE, represented by *Rutilaria*, two cells in girdle view, and one cell in valve view; *Pseudorutilaria*, girdle view of two contiguous half-cells (below), and valve or sectional view (above).

SUB-FAMILY PENNATAE.

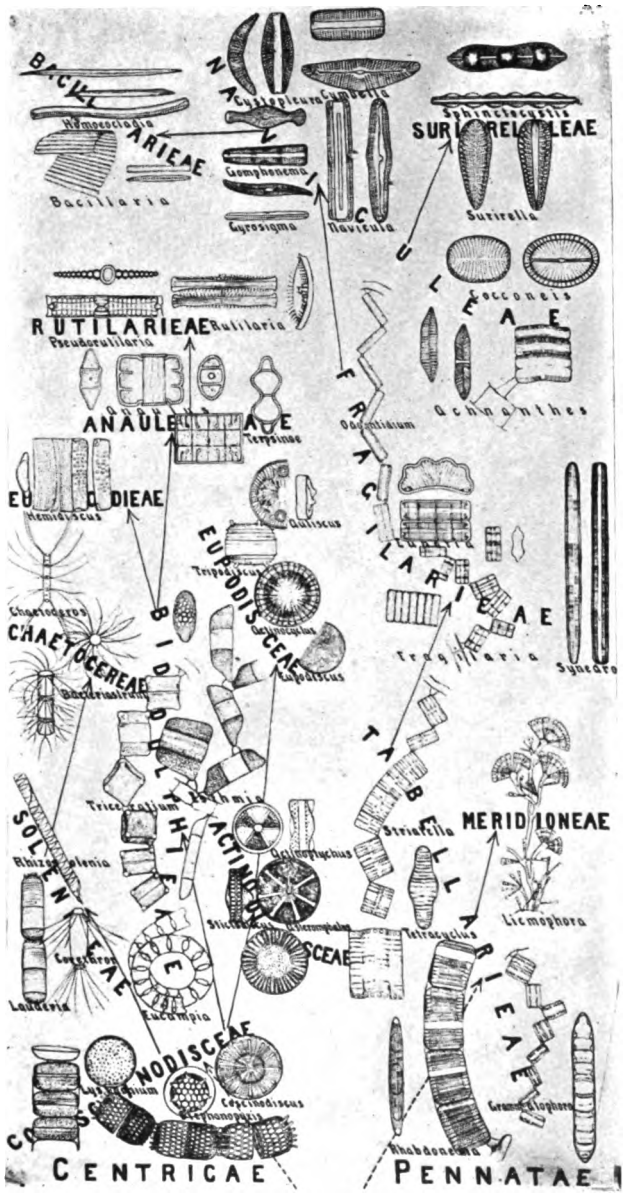
TRIBE X. TABELLARIEAE, represented by a filament of *Rhabdonema* and enlarged valve view, a chain of *Grammatophora* (girdle view) and enlarged valve view, *Tetracyclus* in girdle and valve views, and a broken filament of *Striatella*.

---

* The drawings for this plate were made upon a chart about 1×2 meters, by Miss Edna L. Hyatt, Artist for the Botanical Department of the University of Nebraska, and then photographically reduced to the present dimensions.

Digitized by Google

PLATE V



Digitized by Google

Digitized by Google

TRIBE XI. MERIDIONEAE, represented by several fan-shaped filaments of *Licmophora*, borne on gelatinous stalks.

TRIBE XII. FRAGILARIEAE, represented by broken filaments of *Fragilaria*, and one cell (at the right) in valve view; two cells of *Synedra*, the right in girdle, and the left in valve view; two cells of *Eunotia* in girdle view, and one (above) in valve view, and a broken filament of *Odontidium*, in girdle view.

TRIBE XIII. NAVICULEAE, represented typically by cells of *Navicula* (valve view on the right, girdle view on the left), *Gyrosigma* (girdle view below, valve above), *Gomphonema* (girdle view below, valve above), *Cystopleura* (valve view at left, girdle at right), and *Cymbella* (valve view below, girdle above), and somewhat aberrantly by *Achnanthes* (a short, attached filament at the right and two valve views at the left), and two valve views of *Cocconeis* (lower at left and upper at right).

TRIBE XIV. BACILLARIEAE, represented by a filament of *Bacillaria* (at the left) and two cells (at the right, the upper in girdle view, the lower in valve view); and three cells of *Hemoeocladia*, the lower in girdle view, the other two in valve view.

TRIBE XV. SURIRELLEAE, represented by two cells of *Surirella* (valve view at left, girdle view at right), and *Sphinctocystis* (girdle view below, valve view above).

Digitized by Google

Digitized by Google

NOTICES OF SOME UNDESCRIBED INFUSORIA, FROM THE INFUSORIAL FAUNA OF LOUISIANA.

By J. C. SMITH, New Orleans, La.

WITH PLATE VI.

(Being a Continuation from Page 68 of the Transactions for 1897, and from Page 56 of the Transactions for 1898.)

Family Pleuromonadidae Kent.

Genus Oikomonas Kent.

Oikomonas viridis sp. n. Plate VI, Fig. 1.

Body pyriform, sub-cylindrical, soft and variable in shape; normally less than twice as long as wide; flagellum single, as long as the body and originating in the center of the anterior border; endoplasm enclosing two lateral dark green pigment-bands, which extend for nearly the whole length of the normal body; contractile vesicle distinct and placed to one side of the flagellum, above the pigment-band and in contact with the periphery, the contour of which it distinctly disturbs at each contraction; dark pigment-spot placed above the pigment-band, opposite the contractile vesicle; nucleus roundish and sub-central; food incepted at all parts of the periphery; reproduction by longitudinal fission.

Length 12.5μ; habitat, pond water.

This species was found frequently and at times in great abundance in pond water with several species of filamentous algae. The pigment-bands are distinctly sausage-shaped, and, in color, resemble the endochrome of the alga, *Oedogonium*.

Digitized by Google

It attaches itself to debris or the slide by a caudal-like extension of its substance, which, at times, exceeds the body in length, and when the zooid breaks loose from its attachment, this extension remains for some time, but is always retracted before again attaching itself. It is a very active feeder, and as it always attaches itself before feeding, it generally remains but a short time in the free-swimming condition when food is abundant. The food is of all kinds, and, at times, much longer than its body. The expansion and contraction of the contractile vesicle is quite rapid and cannot escape notice.

This form may possibly be the *Monas viridis* of Dujardin, which seems to have failed of recognition by all subsequent observers excepting De Fromentel. *M. viridis* is the same size. It bears a superficial resemblance to the *Cryptoglena pigra* Ehr., but differs in being soft and plastic, and in the non-possession of an oral aperture. It also bears some resemblance to *Chrysomonas flavicans* Ehr. and to *Chrysomonas ochracea* Ehr., but these forms have a distinct oral aperture and the pigment-bands are permanently yellow.

In size, shape (somewhat), plasticity and manner of taking food, it bears a very strong resemblance to *Chromulina ovalis* Klebs, but differs essentially in the color of the pigment-band, which in *C. ovalis* is yellow or golden, and in the habit of attaching itself preparatory to feeding.

In company with this form were found on several occasions a number of triciliate infusorians (Fig. 3), which the writer is inclined to identify as the *Callodictyon triciliatum* Carter; an infusorian which seems to have evaded all students of these lowly forms since Carter found it at Bombay in 1865. The forms noticed agreed in the transparency and vacuolar construction of the endoplasm, and in the position of the nucleus, which reagents showed to be globular. The anterior depression was absent; the three flagella were equal in size, but nearly as long as the body; the occasional posterior bifurcation was never present in the specimens seen. The body was soft, slowly changeable in shape, but never to any great extent, and food

Digitized by Google

was taken in at any part of its periphery. In size it differed somewhat, being 35.7μ, as against 32.9μ as recorded by Carter. Minus its flagella and movement this form resembles an elongate rayless *Actinophrys*.

Family Heteromitidae Kent.

Genus Heteromita Dujardin.

Heteromita obovata sp. n. Plate VI, Fig. 2.

Body obovate, subcylindrical, plastic and slightly changeable in shape; less than three times longer than wide; the anterior flagellum as long as the body and the posterior one nearly twice as long; contractile vesicle large, active and placed in the posterior third of the body, near the sinistral border; nucleus round, distinct and in the anterior fourth of the body; endoplasm bluish; movements slow and equable.

Length from 16.66μ to 27.8μ; habitat, ditch water.

This form can be easily distinguished from all others of this genus so far described by the position of the contractile vesicle and nucleus.

In shape, relative length of the flagella, position of the contractile vesicle and of the nucleus, this species resembles the free-swimming phase of *Dimorpha radiata* Klebs, but numerous and constant observations have demonstrated that it does not change its character. It is a very active feeder and incepts food at any part of its body. It does this in a peculiar manner. The food is found and pressed to the body by one or both flagella, the body then curves about the food and seems to press it in.

At times the narrow posterior end of the body will throw out one or several filaments of its own substance, by which it fastens itself to the slide and then both flagella are thrown forward to seek food. Occasionally it becomes so filled with food that it loses all semblance to its normal shape, and may then be very nodular. In this respect it resembles *Heteromita globosa* Stein.

Digitized by Google

The form was found in great abundance in ditch-water, and seemed to be very persistent, being taken a number of times during several months from the same spot.

FAMILY HALTERIIDAE Clap. & Lach.

GENUS HALTERIA Dujardin.

Halteria activa sp. n. Plate VI, Fig. 4.

Body subovate, cylindrical, soft and plastic, but persistent in shape; less than twice as long as wide; a spiral wreath of long cilia originating near the anterior border and continued around the body, making a circuit and a half, and ending at the oral aperture, which is near the body-center; oral aperture continued for a short distance as a membranous pharynx; two springing-setae dependent from near the oral aperture, and reaching for some distance below the posterior extremity; contractile vesicle large and latero-central; nucleus round and sub-central; reproduction by transverse fission; movements as with *Halteria grandinella* Müll.

Length 50μ; habitat, brackish water of Lake Pontchartrain.

In consequence of the powerful ciliary wreath, the rotary and forward movements of this species are exceedingly rapid, surpassing those of *H. grandinella*. The springing movement is correspondingly weak, owing to the meager supply of setae. Viewed from the dorsum the springing-setae appear to be caudal appendages, and only by the exercise of much patience can their true nature be demonstrated.

In company with this form were a number of fairly large-sized *Pleuromonas jaculans* Perty, and taking advantage of the favorable conditions, they were given some attention. The apical flagellum was easily demonstrated with an $\frac{1}{8}$ objective, and was never found to be longer than the body of the zooid, and invariably hanging down the concave side. A number were studied with the special object of determining the manner of taking food, and as a result, the writer feels obliged to conclude that this ubiquitous form has a true oral aperture just above the origin of the flagellum by which it attaches itself.

Digitized by Google

FAMILY OXYTRICHIDAE Ehr.

GENUS EPICLINTES Stein.

Epiclintes pluvialis sp. n. Plate VI, Fig. 5.

Body elongate, very elastic, and from five to seven times longer than wide; divided into three distinct regions—a widest central portion which is convex on the dorsal and flat on the ventral surface, a narrower neck-like portion which is very much compressed and rounded at the free anterior border (the central portion usually about twice the length of the anterior portion), and an elongate, attenuate tail-like portion which is subcylindrical and very variable in length; peristome-field elongate-obovate, occupying about one-half the width of the neck-like portion, and extending from near the anterior border to a short distance within the central portion, and there meeting the oral aperture, which is continued a short distance as a distinct membranous pharynx; the peristome-field has a continuous outer marginal fringe of powerful cilia, each of which is longer than one-half the width of the neck-like portion; the inferior or narrower end of this field has for some distance up an oppositely reflexed marginal series of fine pre-oral cilia; the marginal series of body cilia are large, those on the caudal extremity being somewhat larger, the ventral series not numerous, and apparently without definite arrangement; the dorsal surface covered with fairly long hispid setae; contractile vesicle dorsally placed, a little below the oral aperture and near the sinistral border; anal aperture located at the lower ventral extremity of the central portion; movements eccentric; reproduction by transverse fission.

Length 357μ; habitat, pond water.

This large and unique form of the Hypotricha presents a marked departure from all other members of the order in having a symmetrical peristome-field, the same region being more or less arcuate in all other forms described so far. It also bears the distinction of being the first one of the genus *Epiclintes* with a fresh-water habitat. They were taken in large quantities from a small pond at Slidell, Louisiana, with a species of

Digitized by Google

Myriophyllum, and in company with what appears to be a three-horned variety of *Ceratium hirundinella* Bergh. (Fig. 6.) It is a ravenous feeder, and is usually filled with food, in fact the forms observed were so congested that it was impossible, after many efforts, to differentiate the nucleus. In one instance one of the zooids was seen to swallow eight specimens of *Trachelomonas armata* Ehr., which ought to be classed as quite a feat, when the formidable array of spines with which *T. armata* is covered, is considered. It has the peculiar habit of resting alongside of some debris or algal filament, and collecting around its body a quantity of debris, from which it protrudes most of its body when feeding, and into which it withdraws itself when disturbed. This habit is thus exactly similar to that of *Stichotricha aculeata* Wrz.

The *Ceratium* mentioned above is brownish-yellow and measures, full length, 166μ.

FAMILY URCEOLARIIDAE Stein.

GENUS TRICHODINA Ehr.

Trichodina viridis sp. n. Plate VI, Fig. 7.

This ciliate resembles the *Trichodina pediculus* Ehr. in every way excepting that its endoplasm contains numerous small green bodies, not unlike, in shape and general appearance, the chlorophyll of plants. These small green bodies are very much like those contained in the endoplasm of *Paramecium bursaria* Ehr. They are constant, in more or less abundance, and give to the animal a bright green color. The shape is much more compressed than any *T. pediculus* seen by the writer, and resembles a checker used in the game of draughts.

Size varies (diameter) from 76.75μ to 91μ.

Ectoparasitic on the fresh-water snail *Physa integra* Haldeman.

An examination of more than one hundred specimens of the host failed to disclose a single instance of its absence from their bodies.

Digitized by Google

GENUS CONDYLOSTOMA.

Condylostoma culex Smith.

This form was described in these Transactions for 1897, page 63. A further examination has shown that it is only occasionally found with the eggs of *Culex mosquito*, and that its natural habitat is the egg-sac of the pond-snail *Physa integra* Haldeman. A recent examination of a large number of these egg-sacs showed this form present in every instance, and always in large numbers.

Digitized by Google

PLATE VI.

Fig. 1. *Oikomonas viridis.*
Fig. 2. *Heteromita obovata.*
Fig. 3. *Callodictyon triciliatum.*
Fig. 4. *Halteria activa.*
Fig. 5. *Epiclintes pluvialis.*
Fig. 6. *Ceratium hirundinella*—variety.
Fig. 7. *Trichodina viridis.*

Fig. 8. *Notogonia Ehrenbergii.* (See page 95).

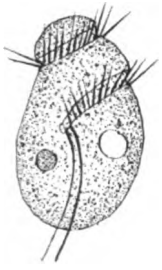
Digitized by Google

PLATE VI

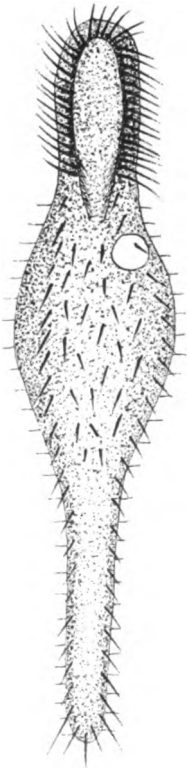
1

2

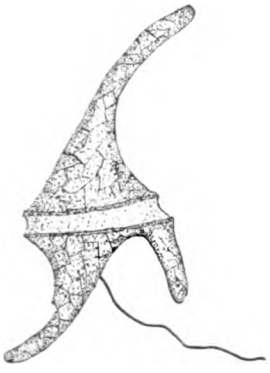
3



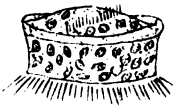
4



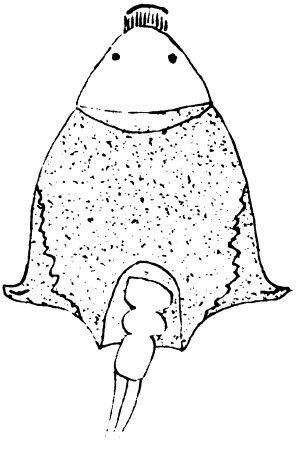
5



6



7



8

Digitized by Google

Digitized by Google

NOTOGONIA EHRENBERGII PERTY.

BY J. C. SMITH, NEW ORLEANS, LA.

WITH PLATE VI, FIG. 8.

Max Perty, in 1852, described and figured a rotifer, which he named *Notogonia Ehrenbergii*. This rotifer not having been again met with up to 1889, and Hudson and Gosse* considering the description not sufficiently explicit, they placed it among their "Doubtful and Rejected Genera."

Up to quite recent years it appears to have escaped the attention of students of this group of animals, for Delage and Hérouard†, in their Vermidiens, place the *N. Ehrenbergii* in their "Incertæ sedis."

In this country, observers seem to have been more fortunate, for Prof. Kellicott‡ has met with it in abundance in Ohio, and about the same time Prof. Jennings§ has quoted it from Lake Michigan.

I have taken it in large numbers from an old unused well in Audubon Park, New Orleans, and having given it considerable attention, deem it not amiss to give a description of this form so that there may be no longer any excuse for ranking it as doubtful.

Lorica transparent, widening backwards, with its posterior border bounded by three concavities; the two outer concavities terminating laterally in thorn-like points, which are directed dorsal-ward and slightly forward; the opening for the head slightly excavate dorsally and much more so ventrally; the open-

* The Rotifera or Wheel-Animalcules, 1889.

† Traité de Zoologie Concrète, 1897, Vol. V.

‡ Rotifera of Sandusky Bay, Journal A. M. S., 1897.

§ Bulletin of the Michigan Fish Commission, No. 6.

Digitized by Google

ing for the foot slightly excavate dorsally and deeply excavate ventrally; ventral plate plain and dorsal plate much arched; postero-lateral borders sub-marginally marked with a zig-zag pattern as in *Metopidia solidus* Gosse; internal anatomy identical with that of *M. solidus*; eyes, two, small, dark, widely separated and placed well up in the head; foot three-jointed; toes slender and almost as long as foot; frontal hood as in *M. solidus*.

Length, including head and toes, 151.5μ; of lorica 114μ; of foot and toes 72.9μ; greatest width of lorica 147μ.

Jennings records this form as *Metopidia Ehrenbergii*, and Kellicott says that he can see no reason for separating it from the genus *Metopidia*. I consider both of these observers to be correct, for this rotifer has as much claim to a position in this genus as the type of the genus itself.

It is an exceedingly handsome animal, and rivals in transparency and distinctness of its viscera, the much-admired *Pterodina patina* Ehr.

It has a peculiar trick of spreading its toes and turning them dorsal-ward while feeding.

The figure given (Plate VI, Fig. 8) was drawn with the aid of a camera, and is a faithful likeness of Perty's original. The size may be considered as corresponding exactly with that given by him.

Digitized by Google

CHLAMYDOMONAS AND ITS EFFECT ON WATER SUPPLIES.

By GEORGE C. WHIPPLE, Brooklyn, N. Y.,
Biologist and Director of Mt. Prospect Laboratory.

WITH PLATE VII.

It is now a well known fact that most of the unpleasant tastes and odors that affect public water supplies are caused by microscopic organisms, and it is somewhat surprising to find that, amidst the host of existing forms, the troublesome organisms are limited to about twenty-five genera. The following table shows the important odor-producing organisms, together with the odors that they impart to drinking water:

Group	Organism	Natural Odor
Aromatic Odor:	Diatomaceae—	
	Asterionella,	Aromatic-geranium-fishy.
	Cyclotella,	Faintly aromatic.
	Diatoma,	Faintly aromatic.
	Meridion,	Aromatic.
	Tabellaria,	Aromatic.
	Protozoa—	
	Cryptomonas,	Candied violets.
	Mallomonas,	Aromatic-violets-fishy.
	Chlamydomonas,	Aromatic-fishy-unpleasant.
Grassy Odor:	Cyanophyceae—	
	Anabaena,	Grassy and moldy-green corn-nasturtiums-etc.
	Rivularia,	Grassy and moldy.
	Clathrocystis,	Grassy and sweetish.
	Coelosphaerium,	Grassy and sweetish.
	Aphanizomenon,	Grassy.
Fishy Odor:	Chlorophyceae—	
	Volvox,	Fishy.
	Eudorina,	Faintly fishy.
	Pandorina,	Faintly fishy.
	Dictyosphaerium,	Faintly fishy.

Digitized by Google

	Protozoa—	
	Uroglena,	Fishy and oily.
	Synura,	Ripe cucumbers - bitter and spicy taste.
	Dinobryon,	Fishy, like rockweed.
	Bursaria,	Irish moss-salt marsh-fishy.
	Peridinium,	Fishy, like clam-shells.
	Glenodinium,	Fishy.
Vegetable Odor:	Diatomaceae—	
	Synedra,	Indistinct vegetable odor.
	Melosira and others,	Indistinct vegetable odor.

Recently it has been found that *Chlamydomonas* is an odor-producing organism. Attention was first called to this by Hollis and Parker,* who found the organism in Spot Pond, Stoneham, Mass.

This pond covered nearly three hundred acres and had a maximum depth of thirty-seven feet, but about one-fifth of the pond had a depth of less than six feet. The bottom of the pond was covered with thick deposits of mud, and the water that entered the pond came partly from a swampy region. These conditions no longer exist, as the pond has been recently acquired by the Metropolitan Water Board, and is being improved and developed as a storage reservoir.

Chlamydomonas was first observed in Spot Pond in August, 1898, but its maximum growth did not occur till November. After Nov. 21st it decreased rapidly, but lingered in small numbers through the following winter and spring. At the time of its maximum growth it was present as follows:

	Number per cc.	Standard Units per cc.†
Surface,	628	156
Mid-depth,	682	171
Bottom,	532	133

It was found that "moderate numbers gave a somewhat unpleasant sweetish and oily taste and odor, and the oily and unpleasant character became more pronounced as the number of

* *Chlamydomonas* in Spot Pond, by Dr. F. S. Hollis and Horatio N. Parker, Journal of the New England Water Works Association, Vol. IV., No. 1, Sept., 1899.

† One Standard Unit equals 400 square microns.

Digitized by Google

organisms increased, becoming fishy and even offensive when high numbers were present."

The writer has had recently the opportunity of corroborating the testimony of Hollis and Parker as to the odor-producing qualities of *Chlamydomonas*, and of noting the occurrence of the organism under conditions very different from those existing in Spot Pond.

The 26th ward of Brooklyn, N. Y., is supplied with water from driven wells, usually pumped directly into the pipes. A reservoir is connected with the distribution system, and is drawn upon whenever the consumption exceeds the amount of water pumped. For the greater part of the time, however, the water in the reservoir is stagnant. The reservoir has a capacity of about five million gallons, and the depth at high water is about eighteen feet. The bottom is of clay, and the slopes are cemented.

On Nov. 16, 1899, the water in this reservoir contained 5120 *Chlamydomonas* per cubic centimeter (equal to 1200 Standard Units), or about eight times as many as were found in Spot Pond. It had a decided green color as seen from above, and a distinct aromatic, almost fishy odor. The odor was much intensified by heating the sample, and after standing a few days, odors of decomposition could be observed. The temperature of the water on Nov. 16th was 8.5° C. On Nov. 21st, the water contained 4248 *Chlamydomonas* per cc.; on the 27th, 1328; and on Dec. 6th, 608. As the organisms decreased the odor became correspondingly less in intensity, though it still retained its characteristic aromatic and unpleasant qualities.

The comparison of the growth of *Chlamydomonas* in Brooklyn with that in Spot Pond is interesting because of the very different character of the water in the two places. This difference is well shown by the chemical analysis on the next page.

It will be observed that while the amount of organic matter is much greater in the Spot Pond water, the nitrogen available as plant food is far greater in the water from the driven wells. *Chlamydomonas* is, no doubt, largely influenced in its food supply by the amount of nitrates present.

Digitized by Google

	Spot Pond (Average for 1897)	Driven Wells of Long Island Water Supply Co. (Nov. 16, 1899)
	In Parts per Million	
Color, (Platinum-cobalt Standard)	0.870	0.000
Albuminoid ammonia	0.273	0.004
Free ammonia	0.021	0.000
Nitrites	0.001	0.003
Nitrates	0.080	9.000
Total residue on evaporation	51.100	279.500
Hardness	20.000	166.000
Chlorine	5.700	28.000

The occurrence of *Chlamydomonas* under conditions differing so widely as in the two illustrations would imply that the organism may develop in almost any pond or reservoir. The early records show that it is a very widely distributed organism, but, with a few exceptions, it has thus far escaped the notice of those biologists who are studying water supplies. There are several reasons for this. The organisms are seldom present in water supplies in numbers sufficient to attract attention by their odor; they are much smaller than most of the common organisms, and the powers of the microscope that are ordinarily used in water examination fail to bring them out with distinctness; and their small size permits many of them to pass through the sand of the Sedgwick-Rafter filter unless an extremely fine sand is used.

The maximum growths of *Chlamydomonas* in Spot Pond and in Brooklyn both occurred during the month of November, but the organism may be found at all seasons of the year. It is frequently present in the reservoirs of the Brooklyn Water Supply during May and June.

Several species of *Chlamydomonas* have been described, but they are of doubtful value. Hollis and Parker stated that the forms observed by them resembled *Ch. albo-viridis* St., but that in some of their phases they resembled several of the nine

Digitized by Google

forms described by Goroshankin.* The forms observed by the writer have agreed in most cases with the figures of *Ch. pulvisculus* Ehrbg. as given by Bütschli. The adult individuals were almost spherical and averaged about 12μ in diameter. The flagella were generally two in number and about twice the length of the body. The cell contents consisted of a single chromatophore, situated near the base of the cell, or cleft and extending forwards; a contractile vacuole near the base of the flagella; a nucleus almost in the center of the cell; certain minute particles said to be starch granules; and oil-globules. As a rule, no eye-spot was visible. The cell was usually surrounded by a thin lorica, but several forms were observed where the entire cell was embedded in a spherical mass of jelly about 30μ in diameter, similar to that surrounding *Haematococcus* Agardh (*Chlamydococcus* A. Braun). In these cases the cells were flask-shaped, the small end terminating at the surface of the jelly and the flagella extending out through a depression in the surface. The length of the flask-shaped cells was 18μ, and the diameter was 12μ. Division of the cells took place, and groups of four, eight, sixteen and thirty-two cells were observed. In most cases the daughter-cells were provided with long hair-like processes, some of them having a length of over 100μ. The daughter-cells were grouped in scattered colonies surrounded by a common sheath, or in compact botryoidal clusters without sheath, and having hair-like processes radially disposed like the pseudopodia on *Actinophrys*.

During the occurrence of *Chlamydomonas* in the reservoir of the Long Island Water Supply, the water at first contained no other organisms except a few *Synedra ulna*, but later rotifers of various kinds became abundant. On Dec. 6th the water contained the following:

	Approximate number per litre
Branchionus pala Ehrbg.....	800
Synchaeta pectinata Ehrbg	400
Anuraea cochlearis Gosse.....	400
Notommata aurita Ehrbg.....	2400

As the number of rotifers increased the *Chlamydomonas* became less abundant.

* Proceedings of the Society of Natural History of Moscow, 1891.

Digitized by Google

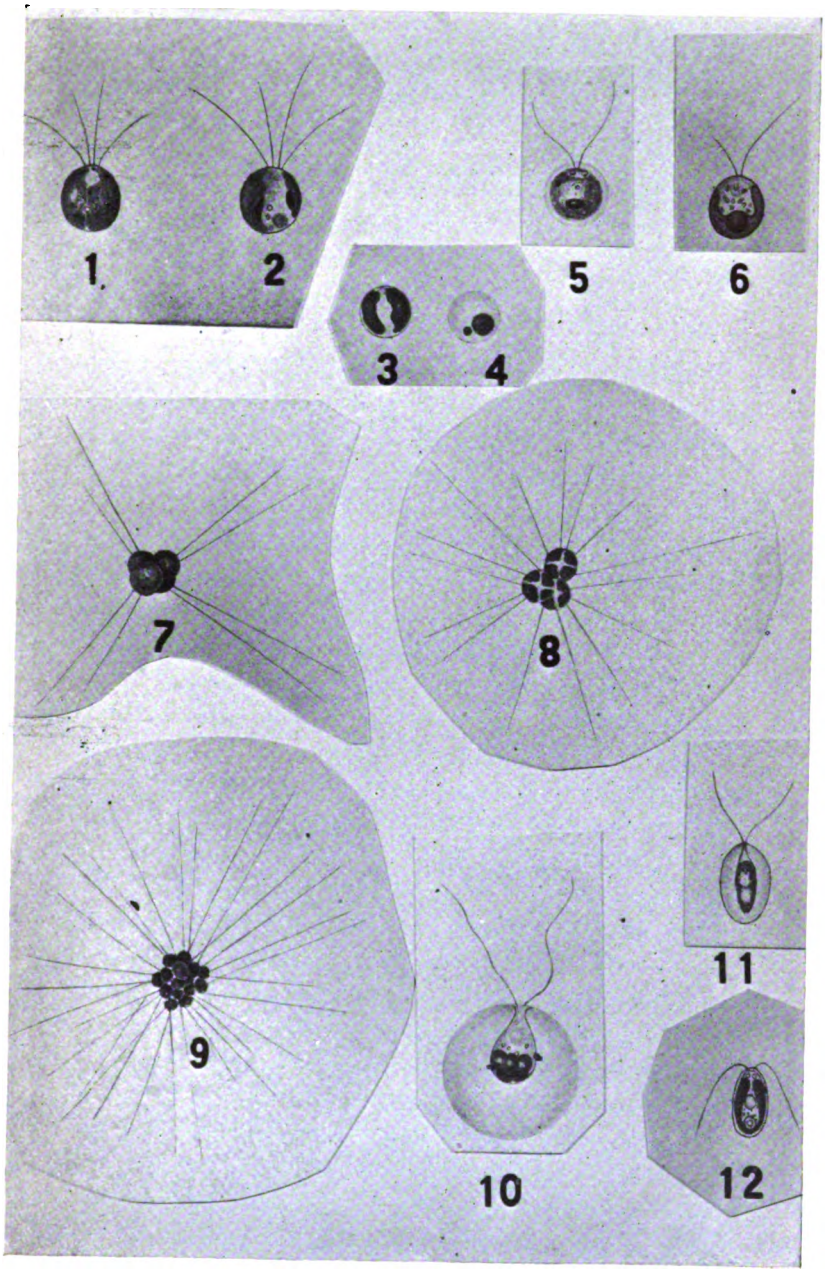
PLATE VII.

EXPLANATION OF FIGURES.

Figs. 1-4. *Chlamydomonas* Ehrbg. After Hollis and Parker.
Figs. 5-6. *Chlamydomonas pulvisculus* Ehrbg. Typical forms.
Figs. 7-9. " " " Divisional forms.
Fig. 10. " " " With gelatinous coating.
Fig. 11. *Haematococcus lacustris*. After Bütschli.
Fig. 12. *Chlamydomonas albo-viridis* St. After Bütschli.

Digitized by Google

PLATE VII



Digitized by Google

Digitized by Google

AN INCUBATOR FOR STUDENT USE.

By VERANUS A. MOORE.

WITH PLATE VIII.

Among the difficulties attending the teaching of bacteriology is the selection of incubators suitable for student use. The majority of those now catalogued by the trade are too small to accommodate a large class. In our most elementary course it has been found necessary for each person to have not less than eighty square inches of shelf room for the boxes or stands for holding test-tube cultures, Petri dishes, and fermentation tubes. In fitting up our student laboratory this necessity was in a measure anticipated and two large incubators built on the Weisnegg pattern were provided. These were found to afford ample shelf room for our present classes, but the difficulty of utilizing the rear half of each shelf soon became apparent. The shelves were necessarily too close together to enable one to reach over cultures standing in the fore part and the result was, that, notwithstanding our cautioning and the intelligent care on the part of the student, it not uncommonly happened that cultures were misplaced, or worse still, pushed from the shelves to the floor with the attending consequences.

In order to overcome the confusion, accidents, and annoyance to students in having their cultures misplaced or perhaps destroyed by others in removing those in their rear, the desirability of constructing individual apartments suggested itself. A number of devices were considered, but the one about to be described seemed to be, all things considered, the most practicable. It consists simply of a chest of drawers very much after the Lillie paraffin-oven pattern which are placed within the incubator, each drawer being of sufficient size to furnish storage

Digitized by Google

for the working cultures of one student. Their use removes all possible excuse for any person meddling with the cultures of others, and they afford convenient trays in which to transfer cultures from incubator to work table and *vice versa*.

The Weisnegg incubators are heated by gas "microbe" burners, placed underneath, the heat being radiated from a metal plate at the bottom and one at the top and the metal tubes connecting them. The tubes are arranged at the two sides and back, and are placed close to each other (see Fig. 1). This arrangement gives lateral heat quite as much as a water jacketed incubator. The shelves with the standards supporting them as seen in Fig. 1 were removed, and in their place the frame work for the drawers was fastened (Fig. 3), leaving a narrow space on all sides.

The drawers were made from sheet zinc with a wooden front. Each drawer is 49 centimeters long, 10.5 centimeters wide and 19 centimeters deep. The sides and rear end are perforated, which allows quite free passage of air. The ends are soldered and the perforations are sufficiently high from the bottom to allow the drawer to hold the cultures if the tubes should, for any reason, break. The drawers can be easily cleaned and disinfected.

The board on the front end of each drawer closes the front of the incubator so that the opening of the door affects the temperature but very little. The drawer is provided at the top with a narrow flange which runs in a metal groove and in which the drawer is supported. The grooved strip is imbedded in the frame work. On the front end of each drawer is an inexpensive but convenient pull which is also provided with a frame for a card on which is written the name of the person who is to use it.

In regulating these the Roux bimetallic regulator is used. It is inserted at the back rather than near the center of the side, as shown in Fig. 1. The size of the drawers might possibly be better if a trifle larger, but as we desired to use the incubator already built, and also to provide for the maximum

Digitized by Google

number of students, the area of each drawer was reduced to the minimum.*

I am indebted to Mr. Henry Bool, who built the drawers, for his skill in minimizing the space occupied by the frame work, and to Mr. Raymond C. Reed of this department for the photographs used in the illustrations.

Department of Comparative Pathology and Bacteriology, N. Y. State Veterinary College, Ithaca, N. Y.

* The incubators have been used for a term of six months since the presentation of this paper. They have fulfilled in every respect all that was expected of them, and as yet no objections to such an arrangement has been found.

Digitized by Google

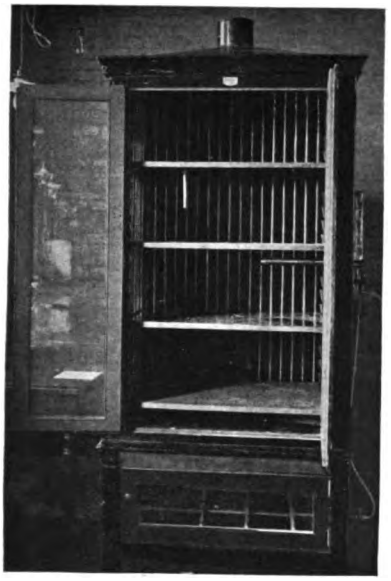
PLATE VIII.

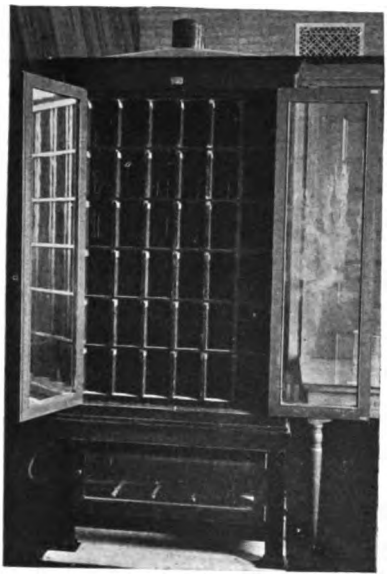
EXPLANATION OF FIGURES.

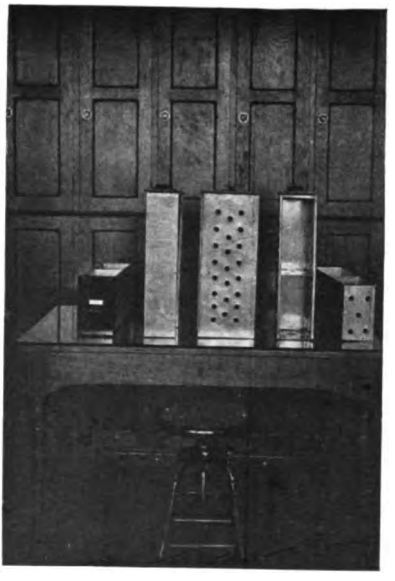
Fig. 1. Photograph of incubator as originally built.
Fig. 2. " " " with apartment drawers completed.
Fig. 3. " " " with frame work for drawers.
Fig. 4. " " " drawers showing different views.

Digitized by Google

PLATE VIII







Digitized by Google

Digitized by Google

SOME LABORATORY APPARATUS.

By SIMON HENRY GAGE.

During the last two or three years the requirements of an unusually large class in the laboratory of Histology and Embryology made it desirable and indeed necessary that some modifications should be made in standard apparatus and facilities in order that the large number should have the same facilities for personally undertaking the principal methods that had been accorded to the smaller number. The first serious difficulty arose in connection with the holders for the paraffin blocks to be sectioned by the Minot ribbon microtome. Each microtome is regularly furnished with three holders of different sizes. For fifty to seventy-five students to use one or even two ribbon microtomes when only three to six holders are available involves so much loss of time in waiting for one another or in hunting up the holders, that it seemed necessary to devise some cheap holder that could be supplied in such quantity that no waiting on that account would be necessary. It occurred to the writer that flat-headed wire nails, cut to the proper length, or flat-headed stove bolts of the right length and size, might be used.

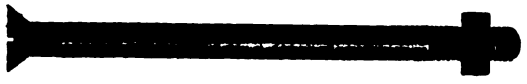


Fig. 1. Flat-headed stove bolt. If a long one is obtained it may be sawed off to avoid the thread at the end.

On investigation the stove bolts (Fig. 1) seemed most appropriate, and these were obtained. For small blocks the bolts answer without modification, but for most of the objects a larger surface than the head of the bolt was necessary. To increase the surface, an American cent was soldered to the head of the bolt. This coin is rough on the two faces so that either one is good for cementing the paraffin block to For still larger sur-

Digitized by Google

faces the old copper cent of the U. S. or copper coins from Canada or Europe were used. For a soldering flux the acid mixture of the tinners was used (i. e., 50 per cent. hydrochloric acid to which some scrap zinc had been added). As the stove bolts vary considerably in diameter it is desirable to take the clamp for the holder to the hardware store and select the bolts that fit properly. In case one dislikes the thread on the end of the bolt—and it is more or less objectionable—a longer bolt may be obtained and cut down to the proper length with a hack-saw. If the cut end is then smoothed with a file, one will have holders as smooth and finished as those sent out by the makers of the microtome. Indeed it is hoped that the makers of the microtome will supply cheap holders. One should get them for at most $5.00 per hundred. They do not cost half that if made as above indicated.

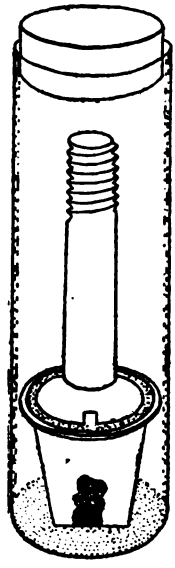


Fig. 2. Shell vial containing a paraffin block cemented to one of the stove-bolt holders The imbedded specimen is indicated by the shading.

The convenience of having plenty of holders has more than fulfilled expectations. Not only are the research students undisturbed with their blocks for series, but in the ordinary laboratory work, if a specimen has proved of sufficient excellence for future use, the block is left on the holder, the end sealed with melted paraffin and the whole placed in a shell vial as shown in the figure (Fig. 2). It can be readily appreciated by the busy director of a laboratory that sections for a class from this block could be obtained with the minimum of time and labor.

Another piece of apparatus urgently needed for a ribbon microtome is a suitable tray or drawer to hold the ribbons. Such a drawer is shown in Fig. 3. If a tray like this is covered by a sheet of smooth paper the ribbons may be laid on the paper as they are cut, and then numbered so that in making the series no mistakes need occur. In addition the name of the object and the thickness of the sections can easily be added.

Digitized by Google

When the tray is filled with ribbons, another similar tray is placed over it to prevent disarrangement of the ribbons by currents of air. With these trays ribbons have been preserved without apparent deterioration for a year in a cool basement. It should be stated, however, that the sections are not so easily straightened with warm water after preserving them so long.

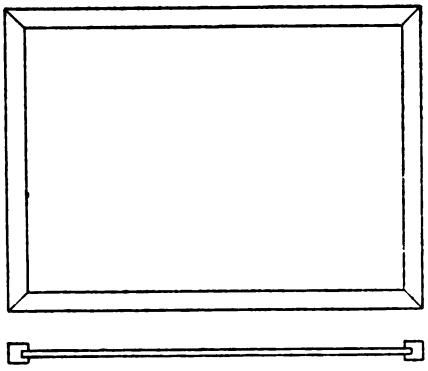


Fig. 3. Tray or drawer of wood for ribbons of sections or for mounted slides. Face and sectional view. (From the Journal of Applied Microscopy.)

These trays were originally designed for storing mounted slides and they were made the size of the laboratory lockers (30x43 centimeters), a size which easily holds fifty slides. Their cost is $12.00 per hundred in Ithaca.

The last piece of apparatus to be mentioned is a receptacle for preparing the dichromate and sulfuric acid cleaning mixture for glass. As is well known this is used by the liter in all chemical, bacteriological and in many histological laboratories. (Formula from Dr. G. C. Caldwell's laboratory guide: Dichromate of potash 40 grams dissolved in 150 cc. of water. To this is slowly added 230 cc. of sulfuric acid.) It was found difficult to prepare this mixture on account of the great heat on adding the sulfuric acid and on account of the corrosive nature of the mixture. Finally a low, flaring iron kettle was selected and lined with heavy sheet lead. The lead is not appreciably corroded and the kettle does not break by the heat. When the mixture is cool it is poured off into bottles.

Histological and Embryological Laboratory, Cornell University.

Digitized by Google

Digitized by Google

AN EXPEDIENT FOR USE IN DIFFICULT RESOLUTION.

By R. H. WARD, M. D., Troy, N. Y.

The resolution of difficult objects, or the effort to decide whether unknown objects are resolvable or not, is often so tedious and even so uncertain in its results, that any plan promising real assistance is interesting. Looking intently through the microscope at a highly magnified object of extremely fine structure, in order to note the effects while experimenting with changes in the illumination, is extremely wearing to the eye and is perhaps the worst way of accomplishing anything that can be done otherwise.

The appearances presented when looking down the tube of the microscope, the ocular having been removed, while sending through the objective illuminating cones of light having various qualities, are familiar as optical curiosities, and they have long been used by makers and others as a means of testing the corrections of the objective and of the illumination; but they have scarcely been employed, certainly not adequately, as a practical assistance in manipulation for the examination of objects. Using an immersion decentering substage condenser and light from an ordinary library table lamp, the illuminated portion of the objective should appear as an intensely bright, white or reddish disc occupying a small portion (perhaps one-fourth to one-tenth of the diameter) of the otherwise perfectly dark backlens of the objective. The whole field should be perfectly free from diffuse light, or with only a trace of blue at the edge opposite the disc. The disc should be sharply defined, and of such size (by graduating diaphragm) and eccentricity (by decentered condenser) as have been found most successful with the optical combination employed; and of course it should be located at a

Digitized by Google

point at right angles to the lines, if any are to be seen. For extreme resolution the illuminating disc should be located at the edge of the field or even partly beyond it, the visible and acting portion then appearing like a half-moon or like the edge-view of a biconvex lens, as shown in the cut.

The writer lately saw this method employed by Mr. Charles Beach of the Catskill Mt. House, in demonstrating, with moderately capable apparatus, *Amphipleura pellucida* and other fine objects. Without focussing on the object, or seeing it at all, the illumination was thus adjusted until the remark was made, "That will show it now," and it did at first glance and every time. It is in remarkable contrast to the tedious work often done, by the really expert, in making the adjustments while intently studying the unresolved object through the microscope.

How far this method would be helpful in the study of objects whose structure is unknown, by enabling the observer to be always certain that he is working his lens at its maximum of resolving power, is an interesting and presumably important field for experiment.

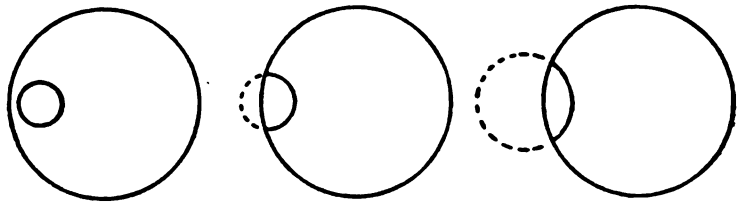


Figure. Oblique illumination by decentered condenser.

Digitized by Google

THE PLANKTON OF ECHO RIVER, MAMMOTH CAVE.

By CHARLES A. KOFOID.

The limestone region of Kentucky covers an area of about eight thousand square miles. A portion of this region, especially in the neighborhood of Mammoth Cave, is devoid of the usual system of streams which afford surface drainage. The St. Louis limestone which underlies the Chester sandstone is honeycombed by caverns hollowed out by the underground water-courses, and the roof of sandstone has fallen in in many places forming sink-holes some of which are several thousands of acres in extent. It is reported, say Hovey and Call ('97), that there are four thousand of these sink-holes in Edmonson County alone. At the bottom of the sink-hole a more or less open passage-way leads to the cavern below. These myriad sink-holes drain off the surface water into the underground water-courses which eventually make their way to Green River, the only open stream of the vicinity. The total length of this underground system is estimated by Professor Shaler, says Packard ('89), to be one thousand miles. Echo River is a part of this subterranean system found in Mammoth Cave, in a tubular cavern accessible for the length of half a mile. Its width, according to Hovey and Call ('97), varies from twenty to two hundred feet. At times of high water the entire cavern is filled by the stream, but at low water, when the stream is most visited, the archway overhead varies in height from five to thirty feet and the depth of the water has about the same range. Barometric observations indicate that the level of Echo River is about twenty feet above that of the local surface stream known as Green River. Experiments with floating chaff have demonstrated that the subterranean water system of Mammoth Cave opens in certain large springs along Green River though I have found no data upon this point pertaining

Digitized by Google

directly to Echo River. It is known, however, that Echo River has some connection with other parts of the water system of the cave.

As above stated the only known source for the water in these cave streams is the surface waters of the neighborhood which make their way through the sink-holes, or by seepage, into the caverns below. The abundance of the sink-holes has prevented any extensive development of surface streams and I have found no reference to "lost" streams in the literature at hand. Hovey and Call ('97) state that many of the outlets of the sink-holes have been closed up artificially to prevent accidents to domestic animals and that this has resulted in the formation of deep pools. It is evident from these facts that the planktonts can have but limited opportunity to breed in the surface waters before they reach the underground system of the cave.

The temperature of the water in Echo River was found by Mr. Hovey (see Packard, '89, p. 9) to be 55° F. on Aug. 13-15, 1881, thus having, at this time at least, about the temperature of the air of the cave and the rock walls (53°-54°). I have found no records of water temperatures at times of flood, or in December, the month in which the collections here reported upon were made.

In December, 1898, Professor C. H. Eigenmann of the University of Indiana made a towing-net collection in the waters of Echo River which he preserved in formalin and kindly sent to me for examination. The collections were made with a net of No. 12 silk bolting cloth, a silk whose apertures will easily allow many of the smaller organisms usually found in plankton to escape. When, however, the pores of the net become clogged with organisms or debris the filtration is more efficient though less rapid. Collections made with nets of this cloth may thus contain representatives of all the organisms present in the plankton but not in their relative numbers.

The total volume of the catch received from Professor Eigenmann after standing twenty-four hours was 1.75 cubic centimeters. It consisted almost entirely of a semi-flocculent

Digitized by Google

sediment, colored reddish brown by the salts of iron from the limestone leachings, together with a few fragments of vegetable debris and traces of finely powdered quartz. Superficial examination revealed a few Entomostraca upon the surface of the sediment while inspection with the microscope increased the evidence for the presence of plankton organisms in the cave waters. All of the material was carefully examined under a low power (35 diameters) and the organisms listed and removed for identification when it was possible. About one-third of the catch was examined under a higher power (175 diameters). The following is a list of the organisms observed together with such biological data as could be gathered from the material:

LIST OF SPECIES IN THE PLANKTON OF ECHO RIVER.

Algae.

Phycochromaceae.

1. *Oscillaria* sp.

Two filaments were found of twenty and fifty-five cells respectively.

2. *Ulothrix* sp.

Three fragments of filaments of fifteen to forty cells.

Bacillariaceae.

3. *Nitzschia linearis* Smith.

A single dead frustule.

Protozoa.

Rhizopoda.

4. *Amoeba limax* Duj.

A single well preserved individual was found which has been referred to this species. It lacks all indications of pseudopodia such as are usually to be seen upon *A. proteus* when taken in plankton and killed in formalin. The body measured 15x45μ, was somewhat wider posteriorly than anteriorly, and was

Digitized by Google

abruptly truncate at both ends. A single well defined nucleus and a number of food vacuoles were visible but no trace of a contractile vacuole could be found. It may be that this is but a form of *A. proteus*, but for the reasons above given it has seemed best to retain Dujardin's name for the form. *Amoeba* has been found by me occasionally in river planktons in company with testaceous rhizopods.

5. *Difflugia globulosa* Duj.

Two specimens of this common rhizopod were found, one of which was but an empty shell while the other was a normal individual. Next perhaps to *D. lobostoma* this species is the commonest of rhizopods in the plankton of rivers. In Lake Michigan also (Kofoid, '95) it is an abundant planktont.

6. *Centropyxis aculeata* var. *ecornis* Leidy.

Two examples only were found, both of which were empty shells. *Centropyxis* is a littoral species abundant among water plants and shore debris. I have rarely found it in living condition in river planktons.

Choanoflagellata.

7. *Salpingoeca amphoridium* J. Clark.

A cluster of six loricae was found attached to the scale of a moth, and two smaller clusters to fragments of vegetable debris. In the individuals examined the neck of the lorica was somewhat shorter than it is in the typical *S. amphoridium*. No trace of collar or flagellum could be detected. *Salpingoeca brunnea* Stokes has been abundant in the plankton of the Illinois River, being found sessile upon *Melosira* and other plankton diatoms and algae. The specimens found lack the truncate base and the brown color characteristic of the typical *S. brunnea*. It has seemed best to refer the form to the variable and cosmopolitan *S. amphoridium*.

Flagellata.

8. *Colacium vesiculosum* Ehrbg.

Rather common upon *Cyclops*, attached to the carapace and

Digitized by Google

appendages. This is an abundant parasite of *Cyclops* in epigean streams.

Suctoria.

9. *Podophrya cyclopum* Clap. & Lach.

Common upon *Cyclops*, especially upon the bases of the antennae and upon the carapace. This form, like the one preceding, is frequent upon *Cyclops* in other waters.

PORIFERA.

10. *Spongilla fragilis* Leidy.

A small number of spicules resembling those of the skeleton of this common species were found. Exact identification is impossible without the gemmulae, of which none were to be discovered. Sponge spicules are frequently to be found in river waters.

VERMES.

Nematoda.

11. ——— ———

A single small nematode worm, evidently young, about 0.35 millimeter in length was found. A single large nematode egg occurred in the collections.

Oligochaeta.

12. ——— ———

A fragment one millimeter in length from the posterior end of a small enchytraeid worm occurred in the collection.

Rotifera.

13. *Rotifer* sp.

But a single rotifer was found in the whole collection. This was a much contracted specimen belonging to the Philodinadae of which, owing to its condition, specific identification was impossible and even generic questionable.

Digitized by Google

ARTHROPODA.

Crustacea.

Ostracoda.

14. *Limnocythere* sp.

Two specimens, one of which was young, belonging to this or a related genus were found. The fully grown specimen had been feeding recently. Ostracoda are frequently found in the plankton of streams though they belong properly to the bottom or to the littoral fauna.

Copepoda.

15. *Diaptomus* sp.

The mutilated and empty carapace of a single specimen was found. Identification of the species was impossible.

16. *Cyclops viridis* var. *americanus* Marsh.

Represented by a single adult female. This is a common summer form in streams and lakes.

17. *Cyclops bicuspidatus* Claus.

This was the most abundant species of the genus and was represented by about seventy individuals of which about two-thirds were adult. The two sexes were about equally represented. The immature forms were principally females and were almost fully grown. Several of the adult females had egg-sacs attached and a number of free eggs were found in the collection. Some of the adult females were unusually large, the length, excluding caudal setae, being 1.75 millimeters. The usual length is a little more than one millimeter. The antennae were somewhat shorter than usual, reaching only to the posterior border of the first segment. The caudal furcae are also somewhat shorter than they often are found, the proportions of length to width being but four or five to one. In river and lake specimens, especially the latter, the furcae may be as much as nine times as long as they are wide. This species is abundant in the Great Lakes and appears in the plankton of the Illinois River during the cooler parts of the year.

Digitized by Google

18. *Cyclops albidus* Jurine.

This species was represented in the collection by about thirty specimens of which but three were males. A single egg-bearing female was found, though but a few of the females were immature. This species also is frequently found in river planktons.

19. *Cyclops serrulatus* Fischer.

But one specimen was found, a small egg-bearing female. The furcae were noticeably curved and divergent and were armed externally with heavy hooked spines. This variable species is widely distributed especially in creek waters.

The facts that the Cyclopidae were present in considerable numbers in Echo River and that some of them were carrying eggs seem to indicate that they might be regarded as normal members of the stygian fauna. A few observations, however, render this inference of questionable validity.

1st. All the individuals examined had eyes which did not appear to differ from normal eyes in any marked degree. Whatever pigment was present in the living animal had been removed by the action of the formalin, as is usual in collections preserved in either alcohol or formalin.

2nd. The proportion of dead individuals represented by more or less disintegrated bodies was large, larger in fact than usual in collections from epigean waters. Several specimens were fungoused and three instances of infection by an opaque whitish spore-like growth, which by some writers has been referred to *Sporotrichum*, were noted.

3rd. The entire absence of nauplii and of the larval stages would suggest that the activity in breeding had been recently checked. The number of eggs present in the ovisacs was frequently below the normal. It hardly seems possible that all the nauplii—if any were present—should have escaped through the net.

4th. Less than ten per cent. of the individuals showed any trace of food contents in the intestinal tract, indicating a suspension of feeding.

Digitized by Google

5th. The species are all common epigean forms and are probably continually carried into the cave by the waters tributary to the cave streams, and are as continually removed by the outflowing currents. Under these conditions these species of *Cyclops* should be regarded as adventitious and temporary members of the cave fauna and not as permanent residents since the conditions of access and the continual changing of the waters do not permit the establishment of a permanent colony.

Hexapoda.

20. ——— ———

A single small dipterous larva, 0.8 millimeter in length, too young for further identification. Dipterous larvae, especially of *Corethea* and of *Chironomus*, are frequently found in the plankton of lakes and streams.

The collection also contained a few insect eggs of three different sizes.

Of the twenty organisms above listed but three are plants, and these not usually found in plankton. They were also present in but insignificant numbers. Of the seventeen animal planktonts, three are Rhizopoda, one a flagellate, and one a suctorian, in all five Protozoa of which but one may be called a planktont. The sponges, nematodes, oligochaetes, and rotifers are each represented by a single species no one of which is a typical plankton organism. Aside from the unidentified ostracod all of the five Entomostaca found occur in the plankton of epigean streams. The single dipterous larva is at the best but an unimportant representative of the plankton. Of the total number of organisms the following only may be cited as typical planktonts:

Difflugia globulosa,
Diaptomus sp.,
Cyclops viridis americanus,
Cyclops bicuspidatus,
Cyclops serrulatus,
Cyclops albidus.

Digitized by Google

The following parasitic or attached organisms are to be classed as passive planktonts:

Salpingoeca amphoridium,
Colacium vesiculosum,
Podophrya cyclopum.

The representatives of the littoral fauna and flora which were found include the following:

Oscillaria sp.,
Ulothrix sp.,
Nitzschia linearis,
Amoeba limax,
Centropyxis aculeata var. ecornis,
Spongilla fragilis,
Nematode worm,
Enchytraeid worm,
Rotifer sp.,
Limnocythere sp.,
Dipterous larva.

The chief characteristics and noticeable features of this collection are the absence of plant life, especially of diatoms, the absence of rotifers, the predominance of Copepoda, and the presence of a considerable range of littoral species, chiefly attached or bottom-living forms.

In addition to the species above listed the collection contained other evidences of life, the scales of Lepedoptera for example being very numerous. These were of a number of different types and were much more abundant than they are in ordinary stream waters. The stellate hairs of the elm (*Ulmus americana*), the spores of *Alternaria*, and comminuted fragments of vegetation were also present much as in surface waters. The collection also contained a noticeable quantity of hyphae and knotted mats of mycelium for which a subterranean origin seems most probable. There were also present a number of the calcareous shells of fossil Foraminifera, derived presumably from the oolitic limestone of the cave.

The plankton of the cave streams doubtless plays an imporant part in the oecology of aquatic cave life since it may be

Digitized by Google

the primal source of the food supply of the larger Crustacea, the blind-fish, and the cave salamanders. The animal plankton which is swept into the cave or which develops in its waters can find little plant life to support it. Plants—other than the fungi—do not seem to thrive in the total darkness, so that any permanently established colony of animal planktonts in cave waters must either depend upon the uncertain accessions of food from the surface waters or adapt itself to the supply furnished by the fungi. The fact that most of the Copepoda in the collection had not been feeding recently would seem to indicate a scanty food supply.

Previous observations upon the microscopic fauna and flora of the waters of Mammoth Cave seem not to have been made upon towing-net collections, and they report other forms than those here listed. With the possible exception of the dipterous larva all the species found in this plankton collection were never before reported from the waters of the cave. Dr. Tellkampf ('45) examined the water of the cave, making some hasty sketches which he later submitted to Professor Ehrenberg of Berlin. This examination resulted in the following list. Under the circumstances the identification is uncertain and no attempt will be made here to enter into the question of nomenclature and synonomy:

From Serena's Bower, 9 miles from entrance of the cave—
Monas colpoda,
Monas socialis,
Bodo sp.
From River Styx—
Chilomonas emarginata,
Kolpoda or *Chilodon cucullus*.

On May 3, 1874, Professor Packard ('89) examined the water in Wandering Willie's Spring, a pool not far from the mouth of the cave, and reports the following as present:

Vibrio,
Colpoda (?),
Nassula or *Prorodon*,
Paramoecium (?).

Digitized by Google

In addition Professor Packard ('89) describes a *Canthocamptus* for which he proposed the name *stygius* from this same spring. No other Copepoda, so far as I can ascertain, have been reported from the cave prior to this paper.

Ehrenberg ('54) in his "Microgeologie" (fide Packard, '89, p. 26), adds to the list of Tellkampf the following:

Biddulphia (?),
Gallionella (?),
Synedra ulna.

The micro-fauna of European caves has been studied by Claus, Joseph, and Schmeil and the fragmentary data of this paper accord well with their more extended results. Thus Joseph ('82) records two "new" species of *Cyclops* from the Carnolian Caves which Schmeil ('94) believes to be *C. albidus* and *C. serrulatus*, two of the species here reported from Echo River. His list also includes *Branchipus pellucidus*, *Estheria coeca*, *Leptodora pellucida*, and *Cypris stygia*. In previous papers he deals with other groups of stygian invertebrates. Of the Rhizopoda he ('79d) finds only an amoeba, which he describes as *A. cellarum*, though in all essential particulars it resembles *A. proteus*. The only other Protozoa found by Joseph ('79b) were some unidentified attached ecto-parasites of the cave Crustacea and other cave animals, and a new member of the Peridinidae, *Peridinium stygium*, which occurred in a pool near the mouth of a cave near Adelsberg. He further states that in a score of years' collecting in caves he has found examples "of more than half of the groups of Infusoria" principally in parts of the caves where bat excrement is found. No specific identifications are given. Of the nematodes he ('79c) records fourteen species from the rubbish at the mouth of the cave, and several others belonging to the genus *Plectus* from the deeper parts of the cave in bat excrement. In Recca Cave another species of *Plectus* occurs. Of the Rotifera nine species were reported from the Karst cave region by Joseph ('79a). These are said to belong, one each to *Trochosphaera* (sic) and *Lepadella*, two to *Hydatina*, and two to a new genus *Apodoides*,

Digitized by Google

while the other three remain unidentified. Specific identifications are not given and it seems probable that the generic identifications are subject to revision. The caves from which these species were secured are said by the author to receive large amounts of flood water in March from surface streams. A single oligochaete *Enchytraeus cavicola* is described by Joseph ('80) from the cave at Potiskavez; this worm was frequently taken from the stomach of the cave salamander.

Schmeil ('94) in a critical paper describes the Copepoda which he secured from the cave region in which Joseph worked. As above stated he concludes that Joseph's species were only well known epigean forms. He finds no particular stygian forms, reporting from Magdalen Cave five species, *Cyclops bisetosus* Rehberg, *C. viridis* Jurine, *C. dybowskii* Lande, *C. serrulatus* Fischer, and *C. prasinus* Fischer. In the living condition some of the individuals showed a marked *reduction in the amount of pigment* in the eye. Claus ('93) had previously reported from Recca Cave five species of *Cyclops*, viz: *C. bisetosus* Rehberg, *C. bicuspidatus* Claus, *C. vernalis* Fischer, *C. strenuus* Fischer, and *C. serrulatus* Fisher. Thus three of the four species here reported from Mammoth Cave have been found in the waters of European caves. In addition to the Copepoda, Schmeil ('94) reports from Magdalen Cave two Ostracoda, both apparently new, belonging to the genera *Cypris* and *Typhlocypris*.

There is little doubt that more extended collections made in various localities in waterways of Mammoth Cave and at different seasons of flood and low water would considerably increase the list of species which make their way into the cave with the surface waters, and may possibly lead to the discovery of some peculiar stygian planktonts, or more likely of some sessile or bottom-living forms of micro-organisms.

The character of this collection renders inevitable the conclusion that the plankton of Echo River—in this instance at least—has been recently derived from epigean waters. It presents few if any typical stygian forms. The recurring access

Digitized by Google

of surface waters provides for the renewal and maintenance of this subterranean plankton and effectually prevents the development of any peculiar cave species. It is also possible that currents of air and visitors might carry into the cave the germs of many minute forms which could there develop when they found proper conditions of moisture within the cave. The additions to the cave fauna from this source must, however, be insignificant in comparison with the ever recurring contributions of the surface drainage.

University of Illinois, Urbana, Ill.

LITERATURE CITED.

CLAUS, C.

'93. Neue Beobachtungen über die Organization und Entwicklung von Cyclops. Ein Beitrag zur Systematik der Cyclopiden. Arb. a. d. Zool. Inst. Wien. Bd. 10, 74 pp. 7 Taf.

EHRENBERG, C. G.

'54. Microgeologie. Das Erde und Felsen schaffende Wirkendes unsichtbar Kleinen selbständigen Lebens auf der Erde. Pp. xxviii, 504, 41 Taf. Leipzig, 1854.

HOVEY, H. C., and CALL, R. E.

'97. The Mammoth Cave of Kentucky: An Illustrated Manual. 112 pp., 25 Pl. and Map. Louisville, 1897.

JOSEPH, G.

'79a. Zur Kenntniss der in den Krainer Grotten einheimischen Räderthiere. Zool. Anz. Bd. 2, pp. 61-64.

'79b. Ueber Grotten-Infusorien. Ibid, pp. 114-118.

'79c. In den Krainer Grotten frei lebende Nematoden. Ibid, pp. 275-277.

'79d. Weitere Mittheilungen aus dem Gebeite der Grottenfauna. Ibid, pp. 305-307.

'80. Ueber *Enchytraeus cavicola* n. sp. Ibid, Bd. 3. p. 358.

'82. Systematisches Verzeichniss der in den Tropfstein-Grotten von Krain einheimischen Arthropoden nebst Diagnosen der vom verfasser endeckten und bisher noch nicht beschreiben Arten. Ber. Entom. Zeitschr. Bd. 26, pp. 1-50.

Digitized by Google

KOFOID, C. A.
'95. A Report upon the Protozoa observed in Lake Michigan and the Inland Lakes in the neighborhood of Charlevoix during the Summer of 1894. Bull. Mich. Fish Comm., No. 6, App. II., pp. 76-84.

PACKARD, A. S.
'89. The Cave Fauna of North America, with Remarks on the Anatomy of the Brain and Origin of the Blind Species. Mem. Nat. Acad. Sci., Vol. IV., pp. 1-156, Pl. 1-27.

SCHMEIL, O.
'94. Zur Höhlenfauna des Karstes. Zeitschr. f. Naturwiss. Sachs. u. Thur. Bd. 66, p. 839-853.

TELLKAMPF, T. A.
'45. Memoirs on the blind-fishes and some other animals living in Mammoth Cave in Kentucky. N. Y. Journ. Med., July, 1845, pp. 84-93, 1 Pl.

Digitized by Google

Digitized by Google

ADDITIONS AND CORRECTIONS

The following indispensable amplifications of :583.1–.2 of p. 161, and of :583.6–.9 and :585.1 and :587 of p. 164, and the accompanying minor corrections, failed to appear in the publication on account of the impossibility of the author's seeing the proofs at the proper time.

CORRECTIONS.

P. 148 Insert ":5i" before "Inorganic Microscopy."

149 Under line ":591" insert ".1 Physiology; .2 Pathology, comparative; .3 Embryology."

After ":591.4 Anatomy" add "and Histology of Organs."

Under ".477" insert ".478."

154 After ":58 Micro-Botany" add "This amplification of Micro-Botany is also intended for **GENERAL BOTANY**, by omitting the "578:"; and it has thus been used by the author for several years. Ex., Climbing plants, 581.54; Osmundiaceae (in modern classification) 585.14."

Line ":016" and the following line should be placed above ":58 General."

156 After " 43 Shoot" add ";439 Bud."

157 Line ".49", bring "Trichomes" into alignment with "Flower" and "Fruit."

Line ".52," add "Cf. :581.926 and .928

158 .811,2, read "Cytoplasm."

159 .871, for "Mostly to" read "Cf."

161 .93-9, after "( )" insert "See table, pp. 174-6."

:583.1 and .2, see amplification on p. 1 of the additions.

164 :583.6-.9, :585 and :587, " " 2 "

Note to :59, for "are those" *et seq.*, read "are with few exceptions from the Zürich amplification."

176 (866), read "Ecuador."

NOTE.

To be inserted in article "Library Expedients in Microscopy" by R. H. Ward in Trans. Amer. Micros. Society, Vol. 21, p. 127-176.

The additions are printed so that they can be cut apart and inserted at the proper page if desired.

Digitized by Google

LIBRARY EXPEDIENTS IN MICROSCOPY.

INDEXING, CATALOGUING, PREPARING AND ARRANGING LITERATURE AND SLIDES.

By R. H. WARD, M. D., Troy, N. Y.

INDEXING.

The advantages of indexing as a library expedient are obvious, universally known, and almost entirely neglected. Even within the limits of an ordinary private library, the constantly increasing mass of useful matter, mixed with and lost in a far greater amount that is practically worthless to the owner, soon outgrows the capacity of the memory to utilize it adequately; to search for it without a guide soon becomes impracticable, to find it by means of the indexes in the various volumes, if there are any, is necessarily tiresome, and also distracting and inconclusive by reason of the alphabetical arrangement where no sensible association of ideas leads and assists the mind, and where the most important material may be overlooked by uncertainty as to the exact words used by an author as a designation. To a thinker the table of contents at the beginning of a volume is a much more agreeable and useful study than the alphabetical index at the close, and it is often the best aid in searching the volume for some desired assistance. The general indexes published at longer intervals by some serials, as our own Proceedings, or collated as in some commercial enterprises, are a valuable assistance but only of limited availability. A general index, like Poole's, which with all its limitations is invaluable, can only apply to some limited field in literature; is almost inevitably subject to the absurdity of alphabetical arrangement, and is necessarily more or less obsolete, and greatly

Digitized by Google

so unless by depending on frequent supplements by which its utility is proportionately reduced.

It may be safely said that any owner of a library, who desires to cultivate any specialty, or indeed to do any literary or scientific work beyond merely reading for the passing pleasure of doing it, ought to incorporate with the subject-catalogue of his volumes, index-references to such chapters, sections or passages, large or small, if not adequately included in the title of the volumes, as he may reasonably expect to wish to refer to, or be reminded of, in the future. Naturally a specialist will include freely references beyond the limits of his own library; and the index will have become, when arranged more or less sensibly, a general catalogue of literary material available and important to himself. This is evidently the substitute, adapted to present conditions, for the wholesale copying of valuable extracts into an index-rerum a generation ago.

CATALOGUING.

For extensive work of this kind a card catalogue is indispensable; and short extracts or hints are much more available if copied onto the cards. It may also be added that important fragmentary notes or memoranda of personal observations or suggestions, or any such information likely to be required for future use, should be written upon cards and classified with the rest.

Of course the cards of the Concilium Bibliographicum at Zürich, and the forthcoming international catalogues of scientific literature, do now, or will in the near future, assist in this work, but not to the exclusion of individual effort; though the early, not to say hasty, repudiation, in the latter case, of any effort to make the enterprise conformable to the decimal system of classification which a rapidly increasing number of us have used extensively with great convenience and profit, is, to speak too mildly, a very great disappointment and discouragement.

Microscopical slides should be catalogued and indexed with the same care, in the same spirit and to the same results, as books or notes; the identical index numbers being used, as a

Digitized by Google

matter of course. Naturally they require the same cross references to points that are important elsewhere than in the groups where the slide has been, on the whole, most advantageously located. There is no objection to using a standard card catalogue for this purpose, except the great waste of room by using cards so much larger than required. Cards 25x75 mm. are amply sufficient, and if not too numerous they may be most conveniently distributed in their proper places among the slides in the object cabinet. If inconveniently many for that, they will occupy but little room when packed in boxes as a card catalogue. Where very few are required, dummy slides may be used, having no mount, but only a label telling in what mount (stating always the index number as well as title) the object can be seen.

PREPARATION OF UNBOUND LITERATURE.

For a public reference library, and for the works in his own line in the private library of a professional man or a specialist, there seems to be no shorter road, royal or plebeian, to the exhaustive results required than the system of cataloguing and indexing hitherto described. The specialist cannot reduce the growing bulk of his outfit by discarding anything in his specialty. Thus the professional microscopist would desire to possess, so far as possible, full sets of every microscopical journal ever published in his own country, and of the most characteristic foreign ones, however much comparatively unimportant matter they might contain; as he can never know when he might wish to refer to something that was formerly considered insignificant. And the same immunity from condensation may well be extended to some but not all of the other, somewhat allied, scientific journals in which he feels most interested.

But in building up his own library one can do far better than this in regard to much of the material that constantly presents itself incidentally. In the mass of mixed literature in the form of general magazines, reports, and various publications that are largely of superficial and temporary value, if any, and which are commonly thrown away when the next number appears,

Digitized by Google

there are, occasionally, portions that are of permanent value, varying in length from a portion of a page, or a cut, up to an elaborate article. If these old numbers are laid aside on the shelves for future use, read or unread, bound or unbound, the useful portions soon become buried in so great a mass of worthless material as to be practically and finally lost unless promptly and thoroughly catalogued by cards; and then the result is so cumbersome that the effort is soon abandoned and an opportunity to acquire an invaluable library is gone. The fact is, according to common observation and experience, that bound sets of ordinary non-professional journals, reports, etc., are among the most unused, and therefore to most persons and for most purposes the most worthless, portions of libraries, excepting only public reference and private specialists' libraries, and small private libraries that contain little else; while the really valuable parts, separated from the rest, may be made one of the most used and useful portions. The remedy for this embarrassment is simple, easy and obvious, but so radical that scarcely anybody seems to think of it, and still less to venture to do it after hearing it recommended. It is merely to keep what is wanted, and keep it in useful form, and discard what is not wanted, without regretting the loss of what is only a burden, or longing for the grand row of volumes the material would make if handsomely bound—at a handsome cost—while well knowing that if the same set, bound, were offered for sale at the cost of binding, the offer would not be considered for a moment. Instead, take them all to pieces, glean out all that might be of future interest to one's self or to anyone likely to come in contact with the collection; and instead of a cart-load, mostly rubbish for all future use, there will remain a handful, more or less, that will be valuable unless spoiled by bad management in rebinding. How far it is wise to apply this radical method will obviously depend upon the taste, judgment and requirements of the person interested.

My own first experience in this direction, some thirty years ago, was most suggestive; and the one lesson proved enough. Having a pile of numbers of one of the miscellaneous maga-

Digitized by Google

zines ready for the binder, it occurred to me to discard portions not wanted and which were not worth house-room, a plan confirmed by a hasty review of a few numbers. The whole pile was dismounted, and the result gave four or five volumes of valuable material, bound up according to the fashion of the time, instead of some three yards of mostly wasted shelf-room. Had the whole set been bound, scarcely a volume would have been taken from the shelf, to this day, except for dusting; while the condensed volumes have been really useful, and would have been far more so but for being spoiled by binding. For years they have been awaiting a convenient time to be taken to pieces, for the individual classification and use of the various papers. Since then I have never been thoughtless enough to fasten together pamphlets that would be more useful apart.

Naturally the same might be said of pasted scrap-books, and of note-books as ordinarily written. Generally, as of bound pamphlets, all they are good for is to be cut up and classified by subjects. This is provided for, however, in some cases, by the note-books where clippings are placed loosely in pockets or envelopes; and by notes written always on separate sheets that can be rearranged at will. The latter can be handsomely accomplished by writing on sheets perforated for tying together near the left margin, like the so-called sermon paper. Slips of card catalogue size would naturally be used for purposes within the limit of their capacity.

It is probably the general belief and experience that unbound literature is a nuisance; and great quantities of it that are really valuable—greater to-day than ever before—are daily thrown away. I hope to be able to convince some of those interested in the subject that it would be at least as nearly true to say that it is the only literature of permanent value that is not more or less of a nuisance. Clearly the aim should be to make everything of the kind a unit, described by a single and simple title that accurately characterizes it; as the fancy titles that give no idea of the subject, which are now so much affected by some otherwise decent journals, are silly, troublesome and disgusting.

Digitized by Google

Authors' separates or reprints of valuable articles on definite subjects, that can be handled and classified independently, are the ideal literature of our day, and the more other things that can be got into the same state of utility, the better. Such a collection, when properly classified, is its own index and its own catalogue. Everything it contains is available with a minimum of trouble.

STORAGE OF UNBOUND LITERATURE.

If only a few things of special importance are to be preserved, those of all sizes from small clippings or memoranda to octavo pamphlets can best be distributed by subjects into stout manila envelopes, and these properly classified between the books of the library, taking care to use envelopes slightly taller than the adjacent books, in order that they be not lost from sight between them; while quartos and larger would be piled horizontally at the ends of some shelves. The familiar sets of envelopes tied into covers, to be handled and stored like note-books, are perhaps convenient for holding a few small scraps; though only in some special cases can they well become a part of an extensive system, as they complicate and embarrass the classification.

For somewhat larger collections, the various sorts of book-like pamphlet cases, to stand on the shelves among the books, and always with covers to exclude dust, would be used instead of envelopes, for pamphlets and extracts of similar size; while the smaller scraps would, in any event, remain in envelopes, and the envelopes, titled and indexed according to their contents, would thereafter be treated exactly as pamphlets on the subjects so indicated.

Pamphlet-cases, however, are clumsy, and waste much room; are awkward to open, empty and repack, unless made to open with a hinge motion at the back instead of a removable cover; are costly if of good quality and used in large quantities; and preserve the contents in poor shape, by reason of the frail papers settling down, by the effect of gravity, during long standing on one end, unless some troublesome arrangement or apparatus be

Digitized by Google

adopted to keep the boxes always stuffed full or the contents pressed firmly against one side.

For large collections the pigeon-hole method seems incomparable, and the writer was glad to abandon everything else many years ago. The pamphlets of every kind, including the envelopes of small clippings or notes, are most perfectly preserved and most rapidly handled, and the space appropriated is most completely utilized. Ordinary book-cases will be found a convenient receptacle. For a beginning a few shelves will suffice; the writer's collection fills five large cases. The shelves should be set about three inches apart; and they should be at least twelve inches wide, which will hold folios lying lengthwise, and smaller sizes crosswise. There is no objection to completing the pigeon-holes by having thin wooden partitions built-in vertically, except that the arrangement is inflexible, causing waste of room and interference with classification. It is far better to leave the shelves wholly free, stacking the material in piles as it will best go in. A careful person can use the piles unprotected without difficulty, or each pile can be tied into a bundle with a small string; but it is best to have movable partitions of sheet tin-plate or other metal, not too clumsy but stout enough to maintain their shape. The sheets are cut 5 or 6 inches wider than required, and the surplus part is bent at right angles, like an L or flange, to lie upon the shelf, where the pamphlets piled upon it hold it firmly enough to keep the whole arrangement wherever it is put.

Of course every pile has on the edge of the shelf beneath it a label announcing its subject and index number; and as these numbers follow each other in regular series throughout the collection, the whole is delightfully simple, sensible, and available, whether it contains a hundred entries or a hundred thousand. The labels must be capable of instant shifting. Label holders that can be bought are often too wide for the thickness of the shelves. A neat substitute is to slip the cards, carefully cut to size, behind the heads of large-headed brass tacks driven just far enough to leave room for the card. For a rectangular card two tacks below and one at each end are required; but the end

Digitized by Google

tacks alone will suffice if the card be suitably notched near the ends, to straddle them. Even a strip of heavy, tough paper lying on the shelf under each pile, projecting in front as much as the thickness of the shelf and bent down in front of it to serve as a label, will suffice.

The great variety of sizes to be shelved without nullifying the classification presents some important problems. As a rule every page should lie flat without folding, and widely different sizes do not stack well together; but many exceptions may profitably be made. If there were in a certain group a large number each of octavo, quarto and folio sizes, it would be best to make three stacks, locating intermediate sizes with the next larger; but if nearly all were quartos, the few folios might be folded (unless having valuable illustrations) and laid in, and the few octavos also inserted, making one series of all. Several smaller scraps from the envelopes, or that would otherwise go there, may often be gummed to a larger paper to which they practically belong; or several of them on an identical subject be gummed lightly (but not irrevocably) inside of a single-fold sheet of note or letter paper, for instance, for convenient classification among others on the same subject.

ARRANGEMENT.

Books, pamphlets, slides, and their catalogues may be arranged either with or without classification. In serial arrangement, without classification, they are numbered, and permanently located in regular order as acquired. Such a catalogue of accessions is the book-list kept, perhaps, by most of careful owners of private libraries. It is useful by reason of incidental memoranda added, and as a means of assigning and recording the serial numbers written in each volume, by which the individual volumes can be referred to. It seems scarcely worth while to include unbound literature in this list, except, perhaps, pamphlets of unusual importance. In case of slides, this list, by leaving ample space to each number, with or without a printed form to fill up, is made to contain any amount of information, simple or elaborate, that may be required by the owner, as to

Digitized by Google

the history, character and treatment of the material and its mount.

Obviously both books and slides might be thus arranged, but the former probably seldom are, by beginners, unless thoughtlessly. In later experience it is not rare to see recent acquisitions stuffed in at the unoccupied ends of the shelves without regard to anything else. This intellectually slovenly habit will be excused, if questioned, by the plea that they are thus more easily gotten at; but it may be safely inferred, in most of such cases, that the rest of the library is little if ever used.

Such an arrangement of slides, however, has been seriously advocated, and is used by some persons. It is argued that as a perfectly natural or satisfactory classification is unattainable, and as it must be supplemented by a reference catalogue as an assistance in finding what is required (always except in the decimal classification), therefore no classification should be attempted, but every slide be located at once and finally in the first vacant space in the drawers, to be found only by catalogue thereafter. The same argument would apply equally to books, and the plan, though not perhaps used for them as a whole, seems to be often employed to supplement a rough and unsatisfactory classification. Whatever advantages such a plan might have, for books or slides, in a great public collection where the objects called for are to be collected and brought to the user by a paid employe, who has nothing to do but to get the things as ordered and afterward to return them to their places, it seems to me beyond reasonable question that every private owner of literature or slides should, for pleasure of handling and for educational effect, have his collection classified in the most rational manner, so that the whole will present itself to his eye and mind as a harmonious whole; each section of it presenting, so far as possible, all that he has at command in regard to its particular subject, and standing adjacent to those most nearly related to itself.

CLASSIFICATION.

Classified arrangement may be based on various characteristics. Buyers of books as furniture often classify them by

Digitized by Google

size, color, or elegance of binding. In such cases, the traditional board in front of each shelf, covered with the representation of the backs of a row of books tooled upon it by a bookbinder, would be preferable; as the purchase for such uses of a set of books, or even a set of dummies representing books, seems a needless extravagance. A cabinet of microscopical slides is sometimes, though perhaps less often, deserving of a similar criticism; but at worst it does generally serve to amuse its owner, which the books referred to do not.

Equally artificial, and only somewhat less unsatisfying, is the venerable alphabetical classification, where the available sections depend wholly upon the combination of letters in words. As the number of such combinations is well nigh infinite, the capacity of the system is indisputably great; and it is still largely employed in libraries. Requiring only the intelligence to recognize the letters of the words and compare their sequence, and leading with mechanical certainty to the object when its name is exactly known, it is claimed to be especially suitable for large public libraries where attendants are employed to bring forward the items called for. When the student does not know exactly what to call for, so much the worse for the student. Probably the attendants, unfamiliar with his exact wants, will assist him as much as they can, but he, at best, is working at a great disadvantage. Exactly in this line, and, so far as it goes, confirming its conclusions, is the recent experience of some of the smaller libraries where the alcoves have been freely thrown open to the public, and all readers have been allowed to loiter among the books shelved on the Dewey system, and to select what they choose after seeing what is offered in any groups which may attract them. To an outside observer this seems to greatly increase the capacity of the library as an educational agency; and it is cordially commended by some, at least, of the officials who have employed it. Alphabetical distribution should, in my judgment, be used as little as possible and as a last resort, in small groups, after a rational subdivision has been carried as far as practicable. As an artificial key it should be tolerated, not courted.

Digitized by Google

Alphabetical classification by authors, either separate or combined in same series with a subject classification, as a key, is a familiar library expedient partly natural but largely artificial. To the microscopist it may be chiefly useful as a check-list of his library, showing which works of each author listed he possesses and which are still desiderata. The most advisable way of preparing such a list, for private use, is to buy such books as F. C. S. Roper's Catalogue of Works on the Microscope, Julien Deby's Bibliotheca Debyana, etc., check the items that are possessed, and write on the blank pages those acquired but not in the list. If an interleaved copy cannot be obtained, it will of course be necessary to have a copy rebound with blank leaves between all the pages. Such a list, being compact and easily handled, is more convenient for frequent use than the more clumsy card catalogue.

The only classification that commends itself to a philosophical mind is by subjects. It should also be a reasonable and practical working system. We need not wait a few centuries more, before beginning, until philosophers have agreed upon the exact relations of all classes of knowledge, nor necessarily begin our scheme with everything pertaining to that part of eternity that preceded the creation of the universe. The indispensable requisite is to have a convenient number, not too many, of convenient classes, conveniently grouped together, with a few great lines of thought running through them, and radiating out into a convenient number of branches that are capable of likewise branching, without limit. This naturally groups together, throughout, that material that will most probably be thought of and studied together; and the location of the material will be naturally led to by the trains of thought occupying the mind at the time it is wanted. This is perfectly simple and obvious, now that it is understood; but it could not have been so stated before the appearance of the decimal system of classification both supplied and elucidated the need.

Many years ago the writer undertook, as doubtless many others did, rather instinctively than conscious of the full effect to be attained, to reach this end by working as numerals the

Digitized by Google

alphabetical letters used in designating the alcoves or other divisions in libraries. This of course produced a twenty-five unit (dropping one letter for the sake of a round number) numerical system, of stupendous proportions, putting quite out of sight the world's little decimal system and the imaginary duodecimal system a longing for which occasionally makes its appearance somewhere. This gave correspondingly grand effects, the first subdivision furnishing over 600 groups, and the third, using only four figures (letter symbols) supplying nearly 400,000. The scheme was soon dropped as too awkward and clumsy for practical use. The employment of letters as figures was not only awkward at first, because of its unfamiliarity, but permanently awkward and liable to errors, from the constant dual use of the symbols (letters) with the confusing and misleading character of the word-like combinations produced; while the groups were too large for convenient memorization, and a burden instead of an aid to the mind seeking light on a particular subject. Why I did not instantly step to the logical conclusion of adopting the familiar decimal system of numerals would be as difficult to explain as it was obviously and confessedly stupid. It is only possible now to claim the common though impecunious excuse that it was no more stupid than other people were. When Melvil Dewey, now Director of the library of the State of New York, proposed to use figures with decimals for this purpose, it was evident enough that this was what was wanted. The figures were among the most familiar things in the world and were used in perfectly simple, direct manner; a few more figures would be required in some cases than with a system capable of multiplying or dividing by 25's, but figures are so familiar to educated people and are so easily handled, that a few more or less are of little importance, and of none compared with the awkwardness of handling much larger groups. And a collection thus managed may be kept always fresh and modern, like the boy's old jack-knife that was always the same familiar and serviceable knife, however many of its parts may have been changed by repairs and renewals. Practical duplicates may be weeded out whenever desired, obsolete

Digitized by Google

pieces may be thrown out, or retained for historical purposes, new material may be added at all times and to any extent, without trouble or confusion. The scheme is simply an unlimited system, that never can be full, always open at every point for any use that may be desired by anybody.

As to the alleged difficulties and impractical character of the system, even a novice having a little literary experience can readily locate his material with some assistance from the synopsis about to be presented.

This seems, to my mind, to be true beyond reasonable question; or would seem so were it not that since this paper was written, and long after its principles had been publicly advocated and notoriously vindicated by a successful and growing use, some highly honored persons, of great character and authority, and of great experience and ability on other lines, have apparently found conservatism irresistible, have been unable to admit the success of so radical an innovation, and have thought it necessary to place a great international enterprise of which they are the honored leaders directly in the way of a successful improvement which is already far advanced in introduction, and which, so far as publicly known, seems to have been agreeable and profitable to those who have used it, and formidable mainly to those who have not.

Though the elaboration of such a scheme is a work of vast complexity and almost unequalled difficulties, it is only justice to say that Mr. Dewey's presentation is remarkable as an ingenious and thorough literary work and practicable as a working manual, equally available for catalogue and for shelving purposes. For general work, exclusive of specialties, it seems to leave remarkably little, considering the circumstances, to be regretted or desired. Its faults are those inherent in any work of broad scope and somewhat permanent character. In the class 5, for instance, of natural science, the material is subdivided in a manner that, needless quibbles aside, is intelligible, convenient and adequate for most well-balanced libraries intended for general use.

Digitized by Google

But a specialist, as such, is not well balanced and cannot be; neither is his library. He has chosen to over-develop himself in one or more lines, and his resources must be made to correspond. He would desire to have at command, so far as possible, everything having an important relation to his specialty. A botanist, for instance, will locate among his professional material, in thought and in housing, things that a chemist, a zoologist or a sanitarian would likewise be interested to place in his own special group. Much additional difficulty is presented by the fragmentary notes and clippings pertaining to fine points, that require a greatly extended subdivision of classes to be really available when wanted.

Especially is this true of such a specialty as Microscopy, which, while small, at least in the suggestion of its name, has relations to a great many lines of human activity and interest. Books, pamphlets, etc., that are possessed solely or even mainly for their value in microscopical chemistry, botany, zoology, etc., from in fact nearly every division of Dewey's classes 5 and 6, and many from beyond those limits, must be at hand in the microscopical library and not scattered among thousands of other books in various parts of the house; or, at least, these and others not owned must be included in the microscopical catalogue, so as to be not only found with a minimum of trouble, but suggested without the labor and uncertainties of search, when wanted. This suggestiveness, which is inherent in the Dewey method, is an invaluable though undervalued peculiarity.

For the classification of slides this system is not only peculiarly applicable, but incomparable; in addition to the great and decisive advantage of having the slides bear the same index numbers as the corresponding literature. In fact the whole scope and utility of the system only become obvious when the same numbers are applied, and serve as a clue, not only to books, pamphlets, clippings and slides, but likewise to the related notes, lecture MSS., diagrams, lantern slides, and illustrative specimens or aids of various kinds; a utilization which the writer and others have employed with facility and

Digitized by Google

satisfaction for many years. For accurately locating the definite points shown in slides, or discussed in fragmentary notes, a subdivision on the Dewey lines but far beyond the Dewey limits is required; and the full tables used by the writer for this purpose will probably be published elsewhere. The following key and synopsis show the plan of the whole and will be of use for every worker with the microscope.*

*Persons desiring the whole Dewey system can obtain it in book form from the Library Bureau, Chicago, Ill., or Boston, Mass.

Special elaborations of Zoology, and of Anatomy and Physiology, which are particularly valuable for microscopical purposes, can be obtained in pamphlet form from the Concilium Bibliographicum, Zürich, Switzerland, as follows:

Tables for use in zoological bibliography..... .....Franc 0.50
" " " physiological " ..... " 1.80
Prospectus of zoological section (English edition).... " 2.00

Library cards on recent publications in Evolution, Microscopy, Paleontology, Zoology, Anatomy, Physiology at 1 to 5 francs per hundred (exact prices are given in Prospectus q. v.).

An interesting pamphlet in French on the decimal classification and its aim, with general abridged tables, is issued as Publication No. 9, by the Office International de Bibliographie, 1, rue du Musée, Bruxelles, Belgium.

Digitized by Google

INDEXING AND CLASSIFICATION IN MICROSCOPY
By The Decimal System

Classes of the Decimal System
Dewey's

0 General		
1 Philosophy	4 Philology	7 Fine Arts
2 Religion	5 Natural Science	8 Literature
3 Sociology	6 Useful Arts	9 History

General Section of Microscopy
Dewey's

578 Microscopy
- .1 Varieties of Microscopes
- .2 Optical Parts
- .3 Mechanical Parts
- .4 Accessory Apparatus and Management of Microscope
- .5 Illuminating Apparatus
- .6 Preparation and Mounting of Apparatus
- .7 Special Preparation and Study of Inorganic Material
- .8 " " " " " Botanical Material
- .9 " " " " " Zoological Material

Key to the Amplified Method in Microscopy
As developed in the annexed Synopsis of Classification

5 Natural Science
57 Biology
578 Microscopy
578.1 Apparatus
578.4 Accessories
578.42 Micrometry
578.429 Standards
578:5 The Microscope in Science
:55 In Geology
:552 Micro-Petrography
:552.2 Volcanic rocks

Digitized by Google

:552.22 Volcanic ashes, etc.
:6 Economic Microscopy
:61 The Microscope in Medicine (In broadest sense)
:614 In Sanitation
:614.3 Study of Adulterations, etc.
:614.32 Milk and its Products
:614.325 Butter and its Imitations

Ex., Discussion of the Am. Mic. Soc.'s standard cm. is 578.429
Verified copies of its rulings, on glass or metal slides, .429
A drawer of Rock sections, or any literature concerning them, :552
Oleomargarine specimens, or related literature, :614.325
In using full tables the last item would have an adjacent number of its own, :614.326

In this system everything is a subdivision of the branch from which it directly springs, 578.04, for instance, being one of the ten possible branches of 578.0; and everything should be classified in the most definite group that will hold it. Ex., (See under Synopsis of Classification), a paper on Microscopy is 578.04; on Microscopical societies, 578.0604; on Slide-cabinets, 578.074; on Teaching microscopy, 578.077; on Microscopical history, 578.0904; on Microscopes, 578.104; on Illumination of projecting microscopes, 578.125; on Uses of the microscope, :604. In all these cases the ".0" or ".04", which are here used freely to show the method of distribution and of subdivision when required, may well be omitted in small collections, as is here done in the instance before the last, and added afterward when the accumulation of material becomes troublesome and requires further sifting.

The analysis given in the following "Synopsis of Classification" is offered as a bird's-eye view of the various fields of microscopical study; to present, especially to the non-professional microscopist, the wide scope of the specialty, and to suggest its many inviting fields for research. It is given in

Digitized by Google

the terms and methods of the decimal system of classification, which has not hitherto been publicly adapted to the special use of microscopists, so far as the writer is aware, to show the utility of the system in microscopy, notwithstanding the too general impression that it is difficult and impracticable; and as an aid to its use by microscopists who are not bibliographers, in the utilization of slides and literature, including fragmentary notes, clippings and cross references.

With a very strong impression of the advantages of uniformity in such work, and of the inconveniences of changing, for however good reasons, figures already used to any considerable extent, the writer has retained as far as possible not only the "Dewey" figures but those of the Brussels and Zürich amplifications, even where it is evidently done, in respect of both theory and practice, at a considerable sacrifice on account of their having been prepared without special provision for the exigencies of microscopy.

Whenever any usage is employed or suggested that differs from the accepted teachings and practice of (public) library economy, it is obviously not for the sake of controversy or even questioning such practice, but to give the writer's preference for a different usage in the case of private owners, especially microscopists, when handling their own material.

As here presented, the subjects pertaining to Apparatus and Technique are found in 578.1–.6, while all of Applied Microscopy is given in a ":" series, in the order of the principal classification.

The subdivision of :5 could be given in 578.7–.9, and can be distributed there by anyone who prefers, as explained in the notes to 578.7, .8 and .9. But circumstances have wholly changed since Section 578 was written and published. The conditions now to be met did not then exist, the microscopy of the present has been created since that time, and its needs were then undreamed of as well as unknown. The subdivision, excessive perhaps for other present purposes, that is required to make the decimal system available for it at all, seems to be best accomplished after the ":". Still more is this true of the

Digitized by Google

:6 series, which could not be forced into 578 otherwise, with even tolerable satisfaction. The following advantages are secured by the arrangement here given. 1. It is most simple and readily understood by the unfamiliar. 2. Everything is directly interchangeable with any decimal service, without any complications. To draw from any "Dewey" library, personal or public, it is only necessary to disregard the ":", as by taking 581.3 when :581.3 is here indicated, and prefixing the ":" if the article is to be permanently assigned here; and, conversely, to transfer from here to the general library, disregard, or for permanent change remove, the ":" from before the section number. 3. In many of the more important groups where subdivision must be carried to a maximum number of digits, from two to three digits are here saved, which, other things being equal, is a decisive advantage.

For literature, the "578" should always be written before the "."; while in a private microscopical library it may be understood, not expressed before ":" which naturally refers to its owner's specialty. It need never be used on a microscopical slide, whose sectional character is obvious; but the characteristic "." and ":" should be carefully retained for maintaining the familiar appearance of the figures as a part of the decimal system. For ease of reading, and prevention of mistakes, the writer prefers keeping the "." invariably in the original Dewey position, after the third figure of the line of principal classification, and likewise marking the third point thereafter, when the line extends beyond that, by a comma as ordinarily used in writing and printing figures.

Paleontology is well provided for in the D. C. :56. But many microscopists, botanists or zoologists, who are not also geologists, have a few specimens of fossils, or corresponding notes which can best be incorporated in their own subjects. These can be distributed in :58 and :59, for instance; as putting sections of fossil wood in :581.4 or :581.8, and fossil ferns in :585.1. But it is often preferred to avoid this scattering of the fossils, and they are often found mixed with the rock sections.

Digitized by Google

To meet this want, the writer has ventured to propose an amplification of 581.9 and 591.9 which does not conflict with any D. C. use, and fortunately coincides exactly with the Brussels scheme of place-subdivisions, though the writer used it publicly in botanic teaching and lectures at least ten or fifteen years before the Brussels Institute was founded. This arrangement brings fossils in the slide-cabinet, very conveniently, immediately after histology; and also provides usefully, for our purpose, for physiographic arrangement in .92.

In Micro-Botany, the writer's amplification of :581 is given to the extent deemed necessary for the present purpose; and in Systematic Botany, :582–9, his indexing is given to the large groups sufficient for a rough preliminary classification, on the new philosophical order as adopted by Britton and Brown. The writer's amplification of the whole of Botany, strictly on the D. C. lines, which he has used on trial for several years, is too large for incorporation here, and will probably be published elsewhere.

Medical Jurisprudence, which lawyers would naturally classify in :340.6, is to most microscopists and physicians not a branch of Sociology but of physical and applied science, naturally of :61, and it is therefore here located in :614.23 where mentioned in D. C.

Microscopical Jurisprudence, a new title, is equally a matter of Economic Microscopy, :6. It is not a branch of Medicine, though closely related to it. As there seems to be no D. C. group that can include it to advantage, nor any unassigned index number in :6, it is here indexed :6j, and placed next to :61 where it belongs. The writer's elaboration of this topic is given in the tables.

It can hardly be necessary to remind beginners that any part of the decimal system which they happen to neither want nor try to use can do them no harm by its alleged complexity or its long figures; and if they should grow into it, by using a few primary groups at first, and then subdividing these at their own convenience and no farther, they would find it easy, and could

Digitized by Google

hardly fail to acquire, meanwhile, a better command of what they have and know, and a clearer conception as to what they want to have and to know. A beginner's collection might well be sorted into six groups, indexed

578.1 Apparatus and its Technique
578.6 Preparation and Mounting
:5i Scientific studies, Inorganic
:58 " " Botanic
:59 " " Zoologic
:6 Economic Microscopy

To which physicians would naturally add

:61 Medical Microscopy.

When any group becomes inconveniently large it would be divided by reference to the synopsis hereafter given, or to fuller tables. When, much later, the need arises for larger figures to specify higher subdivisions, they will be welcomed instead of dreaded.

Digitized by Google

Summary of Microscopy

Arranged by the Decimal System

For permanent use with very small collections, or as an easy beginning with larger. Any or all parts can be readily amplified at any time, while in use, by adding to the objects further figures from the Synopsis following.

See key and explanatory notes on preceding pages.

Note series of ":" following series of ".".

578 MICROSCOPY

General or Mixed Works unclassifiable below

.05 Periodicals

.06 Societies

578.1 Apparatus and its Technique

.11 **Microscopes**

.4 Accessories and their Use

.5 Illuminating Apparatus

578.6 Preparation and Mounting of Objects

578:5 The Microscope in Science

Inorganic Microscopy

:54 Micro-Chemistry

:549 Micro-Mineralogy

:58 Micro-Botany

Unclassifiable, arranged alphabetically here

:581 Physiological and Structural

.4 Anatomy and Histology of Members

.8 Histology

:582 Study of Cryptogams (Spore-Plants)

:583 Thallophytes

.1 Algae; .2, Fungi; .3, Bacteriology; .9, Lichens

:584 Bryophytes

.1 Liverworts; .5, Mosses

:585 Pteridophytes

.1 Ferns; .2, Water Ferns; 3, Equisetums; .4, Club Mosses

Digitized by Google

578:586 Study of Phanerogams (Seed-Plants)
Spermatophytes
:587 Gymnosperms
:588 Monocots
:589 Dicots

:59 Micro-Zoology

General
:591 Physiological and Structural
.4 Anatomy
.477 Integument
1, Hairs; 5, Scales, Exoskeleton; 6, Nails; 7, Feathers; 8, Horns
.8 Histology
1, The Cell; 2, Connective Tissue; 3, Cartilage; 4, Bone; 5, Blood, Lymph; 6, Muscle; 7, Epithelium; 8, Nervous Tissue
:592 Invertebrates
:596 Vertebrates
:597 Fishes
.6 Amphibians
:598.1 Reptiles
.2 Birds
:599 Mammals

578:6 The Microscope in Useful Arts

:6j The Microscope in Law [Microscopical Jurisprudence]

:61 The Microscope in Medicine [Medical Microscopy]

General
:611 Human Anatomy and Histology
.018 Histology
1, The Cell; 2, Connective Tissue; 3, Cartilage; 4, Bone; 5, Blood; 6, Muscle; 7, Epithelium; 8, Nervous System
:612 The Microscope in Physiology
:614.3 Adulterations, etc.
:616 Diseases. Pathology
.96 Parasites
:617 Surgery

:62-9 The Microscope in other Useful Arts

Digitized by Google

SYNOPSIS OF CLASSIFICATION.

For use in arranging microscopical libraries or slide-collections, or as a clue to the more complete tables required by experts. Also as an index to the literature related to microscopy in all libraries, and to the exact numbers where it may be found in those classified on the decimal system.

See key and explanatory notes on preceding pages.

Note series of ":" following series of ".".

578 MICROSCOPY

:016 General Bibliography of Microscopy

General or Mixed Works unclassifiable below, arranged here, A–Z

578.01 Philosophy. Theories

.02 Compends. Treatises

.03 Dictionaries, etc.

.04 Essays, Addresses, Letters, Separates, Reviews

.05 Periodicals. Annuals

.06 Societies and their Proceedings.

Their Journals, etc., to .05

.061 Official Institutions

.062 Scientific, Professional or Social Associations, Clubs, Sections, etc.

1, Transactions; 2, Meetings, Reports; 3, Organization; 4, Membership; 6, Exhibitions, competitions, prizes, etc.; 7, Festivities, excursions, field meetings; 8, Other society enterprises, house, rooms, libraries, cabinets instruments, research and work

.063 Congresses

.064 Expositions

.07 Educational

.072 Laboratories, Experiment Stations, etc.

.074 Museums. Cabinets

.076 Gardens. Aquaria

.077 Teaching

Digitized by Google

578.078 Apparatus, Models, Lecture Charts and Diagrams, Lantern Slides and Illustrative Specimens

.08 Collective Works. Miscellanies

.09 History of Microscopy

Ex., of German Microscopy, 578.0943

.091 Travels, etc., related to Microscopy

.092 Biographies and Addresses of Microscopists

Some would arrrange these with the History, by countries, in .09

See also Biologists, :570.92; Botanists, :580.92; Zoologists, :590.92

578.1 Apparatus and its Technique

.11 **Varieties of Microscopes**

.12 Projection

2, Lenses; 3, Stand; 4, Accessories; 5, Illumination

.13 Simple. Preparing

2, Lenses; 3, Stand; 4, Accessories; 5, Illumination

.14 Compound

.2 **Special Parts, Optical**

2, Reflectors; 3, Objectives, theory, definition, power, nomenclature; 4, Aperture; 5, Immersion; 6, Aberration and Correction; 7, Testing, test objects, micro-ruling and writing; 8, Oculars; 9, Powers of compound microscope

.3 Mechanical. Stands

1, Body; 2, Stage; 3, Substage; 4, Limb; 5, Base; 6, Tail-piece; 7, Coarse adjustment; 8, Fine adjustment; 9, Special stands

.4 Accessories and Use

.41 Drawing

.42 Micrometry

.43 Goniometry

.44 Polariscope

Digitized by Google

578.45 Spectroscope
.46 Erectors
.47 Minor Accessories
.48 Tables, Cases, Outfit
.49 Photomicrography
.499 Microphotography
.5 Illuminating Apparatus
1, Sources of light; 2, Opaque ill.; 3, Dark field; 4, Transparent; 5, Reflectors; 6, Condensers; 8, Special oblique; 9, Binoc ular

578.6 Preparation, Mounting, etc., of Objects

.61 Collection and rough preservation
.62 Examination. Methods, interpretation, errors
.63 Special Treatment
.631 Laboratory, table, apparatus, supplies
.635 Mechanical processes
.636 Treatment of suspended matters, deposits, etc.
.637 Fixing, hardening, softening, etc.
.64 Dissection
.65 Bleaching, staining, clearing
.66 Injection
.67 Section cutting
2, Infiltration; 3, Imbedding; 4, Freezing; 5, Cutting, microtomes, serial sections; 8, Treatment of sections; 9, Hard sections
.68 Mounting
.681 Apparatus, etc.
.684 Manipulation. Arrangement
.686 Dry Mounting
.687 Other media
.688 Finishing. Cements, Varnishes
.689 Repairing
.69 Reconstruction from sections, Models, etc.

578.7 (Special Preparation and Study; Inorganic)
Inorganic Microscopy can conveniently be located here, instead of in :5, if intended to be a very small and subordi-

Digitized by Google

nate department; any required items from :5 to :55 being inserted here by changing :5 to 578.7, or conversely being transferred from here to there by changing 578.7 to :5. See note to :5

578.8 (Special Preparation and Study; Botanic)
Micro-Botany can be located here if desired, transferring any or all of :58, below, by changing :58 to 578.8, or conversely transferred from here to there by changing 578.8 to :58. See note to :5

578.9 (Special Preparation and Study; Zoologic)
Micro-Zoology; same note as to 578.8, above, reading :59 for :58, and .9 for .8. See note to :5

:84 The Microscope in Law; see :6j

578:5 The Microscope in Science

(Special Preparation, Study and Description)
See explanatory notes following the "Key to the Method"

:5i Inorganic Microscopy

:54 Micro-Chemistry

:546 Inorganic Chemicals. 1, Non-metallic; 2, Metallic

:547 Organic Chemicals

:548 Crystallography

:549 Micro-Mineralogy

:55 Micro-Geology

:552 Micro-Petrography
.2, Volcanic rocks; .22, Volcanic ashes, etc.; .3, Plutonic; .4, Metamorphic; .5, Sedimentary; .6, Meteorites; .7, Decay of rocks

:553 Economic Geology
.2, Carbon series, peat, coal, fossil resins, etc.; .3, Iron ores; .4, Other ores; .6, Earthy economic minerals; .7, Mineral water deposits; .8, Gems

:56 Micro-Paleontology
See notes after "Key to the Method"

:561 Fossil Plants
Here, or, for small collections, to :58

:562 Fossil Invertebrates
Here, or, for small collections, to :59

Digitized by Google

578:566 Fossil Vertebrates
Here, or, for small collections, to :59

:57 **Micro-Biology**
Mostly to :58 and :59

:58 **Micro-Botany**
See notes after "Key to the Method"

:58 General
:580.1, Philosophy, Nomenclature; .2, Compends, Treatises; .3, Dictionaries, etc.; .4, Essays, Addresses, etc.; .5, Periodicals; .6, Societies; .7, Study and Teaching; .72, Laboratories, Experiment stations; .73, Bacteriology, to :583.3; .74, Museums, Herbarium work; .76, Botanic gardens, Aquaria; .77, Teaching, Pedagogy; .78, Apparatus, etc., of instruction; .8, Collective works, Miscellanies; .9, Botanic History; .91, Travels related to Botany; .92, Biographies of Botanists

:016 Bibliography
Unclassifiable, arranged here A–Z

:581 Physiological and Structural
.1 Physiology
.11 Nutrition
.111 Plant Constituents and Food
.112 Absorption and Conduction
.112,9 Movements of Gases
.113 Transpiration
.114 Photosynthesis; 9, Metabolism
.115 External influences
.116 Special processes. Cf. Ecology, :581.5
.117 Saprophytes. 8, Parasites. 9, Insectivoræ. 95, Symbionts
.12 Respiration. 1, Temperature; 2, Phosphorescence
.123 Products

Digitized by Google

578:581.124 Distribution. 5, Storage. 6, Utilization. 69, Waste
.127 Growth
.128 Periodicity
.129 Development of Members
5, Adventitious growths; 8, Wounds and Repair; 9, Grafting, cf. :634
.13 Movements
1, Stability; 3, Elasticity; 5, Turgidity; 7, Tensions
.139 Mechanical tissues
.14 Curvature movements
.141 Hygroscopic curvatures
.142 Growth curvatures
.143 Nutation. 4, Heliotropism. 5, Hydrotropism. 6, Geotropism
.147 "Orthotropism". 8, Coiling
.15 Motions of Organs
1, Sensitive plants; 2, Insectivoræ; 5, Gyrations; 7, Sleep of plants
.159 Locomotion. Cf. Cytology, :581.81
.16 Reproduction
1, Individuality; 2, Longevity; 3, Death; 4, Permanence of Protoplasm. Cf. :581.81
.166 Vegetative Propagation
.168 Budding. 9, Spore formation
.17 Sexual Reproduction
1, Differentiation of sex; 2, Alternation of generations
.173 Parthenogenesis
.175 Fertilization
.176 Pollination. 7, Cross fertilization. 8, Hybridization
.18 Reproduction of Thallophytes
.181 Conjugation
.182 Oophytic

Digitized by Google

578:581.183 Carpophytic
.185 Of Archegoniatae
.186 Bryophytes and Pteridophytes
.187 Antherozoids
.188 Egg cells
.189 Gymnosperms
.19 Of Siphonogamae
.191 Pollen plants
.2 Pathology
.22 Teratology
.3 Embryology. Ontology
.31 Ovule
.32 Fertilization
.33 Embryo
.34 Development. Histology
.35 Morphology
.36 Vitality
5, Longevity; 9, Continuity of embryonic substance
.37 Germination
1, Time; 2, Conditions; 3, Effects
.38 Seedling
.39 Ontological development
.4 Morphology, Anatomy [and Histology of Members]
Cf. Histology, :581.8. Care is required to avoid maintaining duplicate series here and there. All histology that is separable should go there, unless a non-botanist having a few sections, etc., that show distribution of tissues (:581.85–.89) should prefer to employ the simpler and easier classification here, for all.
.41 Thallus
.42 Root
.43 Shoot
.44 Stem
.449 Branching
.45 Leaf

Digitized by Google

578:581.46 Flower
.463 Perianth
.464 Calyx
.465 Corolla
.466 Stamens
.467 Pollen
.468 Pistils
.47 Fruit
.48 Seed
.49 Trichomes. Emergences, etc.
.5 Habits. Ecology
.51 Climate-relations
.52 Aquatics, etc.
.53 Drouth Plants
.535 Salt-region Plants
.54 Climbing Plants
.549 Epiphytes
.55 Saprophytes
.56 Parasites, etc.
.57 Carnivorous Plants
.58 Symbionts
.59 Protective Adaptations
.6 Economic Botany
.61 Food-stuffs
.62 Food-adjuncts
.63 Medicinal Plants

For general students, here; for medical, to :615

.64 Oils, Waxes, etc.
.645 Gums, Resins, etc.
.648 Dyes, etc.
.65 Tanning Materials
.655 Fibers, etc. Cf. Manufactures, :67
.66 Wood. Cf. Forestry, :634.9
.669 Barks
.67 Fodder Plants, etc.

Digitized by Google

578:581.68 Other Products from,
1, Thallus, Cryptogams; 2, Root, tuber, etc.; 3, Shoot; 4, Stem; 5, Leaf; 6, Flower; 7, Fruit; 8, Seed; 9, Hairs, etc.

.69 Injurious Plants. Mostly distributed elsewhere

.8 Histology

.81 The Cell. Cytology

.811 Protoplasm (Energid)
1, Nucleus; 2, Cyptoplasm; 5, Plastids; 8, Continuity of protoplasm; 9, Cell nutrition and growth

.812 Cell Wall and Morphology

.812,5 Forms

.813 Thickenings, etc.
2, Collenchyma; 3, Sclerenchyma; 4, Tracheids; 6, Irregularities, 7, external, 8, internal, pits, reticulations, rings, spirals, etc.; 9, Cystoliths

.814 Transformations

.815 Non-nitrogenous products and contents
1, Starch; 2, Inulin; 5, Caoutchouc; 7, Oils; 8, Resins; 9, Crystals, etc.

.816 Nitrogenous products and contents

.816,5 Crystalloids

.817 Cell Movements
1, Irritation; 2, Streaming; 3, Rotation; 5, Creeping; 6, Cilia; 7, Flagella

.818 Cell Formation. Reproduction
1, Nuclear division, karyokinesis; 3, Cell-division; 4, Free cell-formation; 5, Cell-budding; 6, Conjugation

.819 Age and Death of the Cell

.82 Cell Families (Cohesions)

.821 Cell Fusions

.822 Fertilization. 3, Plasmodium. 4, Hyphae. 5, Sieve-tubes. 6, Latex-tubes. 7, Vessels

Digitized by Google

578:581.83	Tissues and Tissue Systems
.831	Cell-building. 6, Cell-connection. 7, Spurious tissues
.838	Meristem
.839	Fundamental tissue
.84	Tegmentary system
.841	Epidermis. 1, Incrustations; 2, Exudations, secretions; 4, Coloration; 5, Stomata; 6, Water-pores; 7, Trichomes, Emergences, Glands, etc.
.843	Vascular Bundle system
.844	Distinct bundles. Phloem, Xylem
.847	Conjoint bundles. Concentric, Collateral, Closed, Open
.85	Distribution of Tissues
.851	Ontogeny and Phylogeny
.855	In Thallophytes
.856	Bryophytes
.857	Pteridophytes
.858	Phanerogams
.859	Embryo
.86	Root
.861	Epidermis, hairs, cap, sheath
.864	Primary cortex, exodermis, endodermis
.866	Central cylinder, pericycle, vascular strands
.869	Medullary tissue
.87	Stem
.871	Epidermis. Mostly to :581.841
.872	Primary cortex
.873	Hypoderma, fundamental tissue, endodermis
.874	Primary central cylinder
.875	Pericycle
.876	Vascular bundles. Phloem Cambium, Xylem

Digitized by Google

578:581.877	Bundle sheath, Bundle-strands, Medullary sheath
.878	Medulla (pith). 9, Medullary rays
.88	Secondary tissues
.881	Secondary growing points and meristem
.881,2	Adventitious growths
.882	In Monocots
.883	Fundamental tissue
.884	Scattered vascular bundles
.885	Cambium ring
.886	Gymnosperms and Dicots 1, Leaf bundles; 2, Cauline
.887	Bast 1, Cortical rays; 2, Periderm; 3, Cork; 4, Bark; 5, Lenticels; 6, Leaf-scars; 7, wound-cork, etc.
.888	Cambium
.889	Wood
.889,1	Seasonal growth. Annual rings
.889,3	Sap wood. 4, Heart wood
.889,5	Medullary rays
.889,6	Coloration
.889,7	In Gymnosperms
.889,8	Anomalous thickenings
.889,9	Knotted, curled, etc.
.89	Leaf
·891	Epidermis. Mostly to :581.841
.892	Fundamental tissue
.893	Leaf bundles
.894	Flower
.895	Perianth. 6, Stamens. 7, Pistils,
.898	Fruit. 5, Seed
.899	Trichomes. Emergences. Glands

Digitized by Google

:583.1 Algae

.11 Cyanophyceae (Blue-green Algae)

.12 Chlorophyceae (Green Algae)

.13 Protococcales

.14 Siphonales

.15 Conjugatales

.153 Desmidiaceae

.154 Diatomaceae

A good arrangement for diatoms in a slide-cabinet, would be:—(*a*) Special preparations showing methods or results of mounting, etc. (*b*) Opaque mounts, and those *in situ* in deep cells. (*c*) Specially selected and verified test objects. (*d*) Named Genera, alphabetically, or classified according to Prof. C. E. Bessey's paper in same Vol. (Proc. Am. Mic. Soc. 1899). (*e*) Unnamed or mixed mounts, ( ), see pp. 174–6.— Ex., Strewn diatoms from Hawaii, :583.154(969). The index No. of diatoms, :583.154, should be written on the drawers containing them, but is needless on the slides whose character is obvious. When the drawers are numerous they may be marked *a*, *b*, *c*, *d*, ( ), etc., for the groups above named or for others desired. The slides may be marked with a fine pen in red ink with the same group letters, also underlining in red the first letters of the genus in group *d* for alphabetic arrangement, and giving the geographic index complete in group *e*, as (969).

.16 Confervoidales

.17 Phaeophyceae (Olive-brown Algae)

.18 Rhodophyceae (Red Algae)

.189 Corallinaceae

.2 Fungi

.21 Myxomycetes (Slime Fungi)

.3 Schizomycetes (Fission Fungi. Bacteria)

(As given in the Synopsis, pp. 161–4)

Digitized by Google

Digitized by Google

578:581.9 Distribution of Plants
.91 Geologic (Phytogeology). cf. Paleontology, :561
Div. like :581.4, or like :582-9
.92 Physiographic. ( )
See Table of Geographic Subdivisions
.93 Geographic (Phytogeography)
.930,1 Principles. Theories
.930,11 Local conditions. Moisture, temperature, soil
.930,12 Zones of Latitude and Altitude
.930,15 Distribution. By winds, streams, animals, man
.930,16 Limitations. Mountains, deserts, oceans
.930,17 Insular. 18, Polar
.930,19 Regions of Vegetation
.93-9 Floras, etc. ( )
Ex., Plants of Florida, :581.9(759)

:582 Study of Cryptogams (Spore-Plants)
The index numbers here given in the systematic classification are adapted to the philosophical arrangement, corresponding to that universally employed in zoology, which did not exist when the Dewey system was published. Britton and Brown's Ill. Flora of the Northern United States, etc., is taken as a standard for the order, so far as it goes. Those preferring the former classification can of course obtain it from the Dewey books.

:583 Thallophytes
.1 Algae
.2 Fungi
.3 Bacteriology
This analysis is not intended for those professional bacteriologists who may prefer to classify with regard to their own work or their latest theories; but it is offered as a practical scheme for the

Digitized by Google

convenience of others in arranging their literature, references and specimens.

Bacteriology is here given as a whole, on the D. C. methods but with original numbering. Medical specialists can, if preferred, readily transfer the whole, or only the Medical Bacteriology, .53-.59, to :610.73.

578:583.3:016	Bibliography
.307	Technique
	3, Staining; 5, Cultures; 7, Sterilization; 9, Photomicrography, cf. 578.49
.31	Physiologic Bacteriology
.311	Identification. Pseudo-Bacteria
.32	Cytology, etc.
.33	Association
	Chains, filaments, swarms, zoogloea, mycoderma, precipitate-condition
.34	Origin; 5, Dissemination
.35	Reproduction
	1, Fission; 5, Spores; 8, Variation; 9, Polymorphism
.36	Nutrition. 1, Aliments
.37	Conditions; 9, Luminosity
.38	Products
.389	Movements
.39	Effects of physical agents
.4	Systematic Bacteriology
.41	Micrococci (Spherobacteria)
.42	Chromogenic species
.43	Zymogenic species
.44	"Monads"
	Pathogenic species, to Medical Bact., :583.53, unless preferred to keep all in one series
.45	Bacilli (Rod-like forms)
.46	Spirillae (Spirobacteria)
.5	Economic Bacteriology
.51	Bacteria in Fermentation. Cf. :583.38 and :663

Digitized by Google

578:583.52	Bacteria in Putrefaction. Cf. :583.38
.529	Nitrification. Cf. :581.111 and :583.546
.53	Bacteria in Medicine. Medical Bacteriology
.530,7	Experiments on animals. Vivisection
.531	Infection. Susceptibility. Immunity
.537	Pathogenic Micrococci
.538	Pathogenic Bacilli
.539	Pathogenic Spirillae
	The last three divisions are for general discussions only, or for the arrangement of very small collections. The following subdivisions are for more extensive work.
.54	Bacteria in Hygiene and Sanitation. Cf. :614
.541	In Air
.542	Of various places
.543	Of various employments
.544	On clothing, etc.
.545	On surface of the body
.546	In the Soil. Cf. :581.111 and :583.529
.547	In Food
.548	In Drinks
.549	In the stomach and intestines. Cf. .563
.55	Bacteria in Pharmacy
.555	Antiseptics, Disinfectants, etc.
.56	Bacteria in Disease. Cf. :616
.561	Of Circulatory system
.562	Respiratory system
.563	Digestive system
.564	Lymphatic system
.565	The Skin. Dermatology
.566	Genito-Urinary system
.567	Organs of Locomotion
.568	Nervous system
.569	General Diseases
	Cf. and div. like :616.9 if required

Digitized by Google

578:583.57 Bacteria in Surgery
.572 Suppuration. Tetanus
.576 In Dentistry. The Teeth
.577 Ophthalmology. The Eye
.578 The Ear
.579 Military Surgery
.58 Bacteria in Gynecology
.582 Obstetrics
.59 Bacteria in Comparative Medicine
Cf. and div. like :619
.9 Lichens
:584 Bryophytes
.1 Liverworts
.5 Mosses
:585 Pteridophytes
.1 Ferns
.2 Water Ferns
.3 Equisetums
.4 Club Mosses
:586 Study of Phanerogams (Seed-Plants)
Spermatophytes
:587 Gymnosperms
:588 Monocots
:589 Dicots
.1 Choripetalae, "Apetalae"
.2 " "Polypetalae"
.7 Sympetalae, Gamopetalae

:59 Micro-Zoology

The figures throughout Zoology, :59, when in excess of the D. C., are those of the Zürich amplification, except .91

General

:590.1, Philosophy, Nomenclature; .2, Compends, Treatises; .3, Dictionaries, etc.; .4, Essays, Addresses, etc.; .5, Periodicals; .6, Societies; .7, Study and Teaching; .72, Lab-

Digitized by Google

:583.6 Phycomycetes (Algal Fungi)
.61 Oomycetes
.66 Zygomycetes (Mould Fungi)
.7 Ascomycetes
.71 Hemiasci
.72 Exoasci
.73 Carpoasci
.74 Cleistomycetes
.77 Pyrenomycetes
.79 Discomycetes
Ascolichenes to .97
.8 Basidiomycetes
.81 Hemibasidia (Brand Fungi)
.84 Basidiomycetes
.88 Hymenomycetes
.89 Gasteromycetes
Basidiolichenes to .98
.9 Lichens
.97 Ascolichenes. Div. like .7
.98 Basidiolichenes. Div. like .8
:585.1 Filicinae (True Ferns)
.11 Ophioglossaceae
.12 Marattiaceae
.13 Isoetaceae (Quillworts)
.14 Osmundiaceae
.15 Gleicheniaceae
.16 Hymenophyllaceae
.17 Schizaeaceae
.18 Cyatheaceae
.19 Polypodiaceae
:587 Gymnosperms
.1 Cycadales
.2 Ginkgoales
.3 Coniferae
.4 Taxaceae
.41 Podocarpeae
.49 Taxeae
.5 Pinaceae
.51 Araucarineae
.6 Abietineae
.7 Taxodineae
.8 Cupressineae
.9 Gnetales

Digitized by Google

Digitized by Google

oratories, Experiment stations, Dissection, Vivisection; .73, Bacteriology, to :583.3; .74, Museums; .76, Zoologic Gardens, Aquaria; .77, Teaching, Pedagogy; .78, Apparatus, etc., of instruction; .8, Collective works, Miscellanies; .9, Zoologic history; .91, Travels related to Zoology; .02, Biographies of Zoologists

578:591 Physiological and Structural
- .1 Physiology
- .2 Pathology
- .3 Embryology
- .4 Anatomy [and Histology of Organs]
- .41 Circulatory Organs
- .42 Respiratory Organs
- .43 Nutritive Organs
- .44 Lymphatic System
- .46 Genito-Urinary Organs
- .47 Motor Organs
- .477 Integument
- .478,1 Hairs
- .478,5 Scales, Exoskeleton
- .478,6 Nails
- .478,7 Feathers
- .478,8 Horns
- .48 Nervous System
- .49 Somatology
- .5 Habits of Animals. Ecology
- .6 Economic Zoology
- .8 Histology
- .81 The Cell. Cytology
- .82 Connective Tissue
- .83 Cartilage
- .84 Bone
- .85 Blood. Lymph
- .86 Muscle

Digitized by Google

578:591.87 Epithelium
.88 Nervous Tissue
.9 Distribution of Animals
.91 Geologic
.92 Physiographic
.93-9 Geographic
:592 Invertebrates
:593.1 Protozoans
.2 Radiates
.3 Coelenterates
.4 Sponges
.5 Cnidaria
.6 Actinozoa
.7 Hydrozoa
.8 Ctenophora
.9 Echinoderms
:594 Molluscs
.1 Bivalves
.2 Scaphopods
.3 Gastropods
.4 Pteropods
.5 Cephalopods
.7 Polyzoa
.8 Brachiopods
.9 Tunicates
:595 Articulates
.1 Worms
.11 Parasites
.14 Annelids
.18 Rotifers
.2 Arthropods
.3 Crustaceans
.31 Entomostracans
.35 Cirripedia
.36 Malacostraca
.4 Arachnidans
.6 Myriopods

Digitized by Google

578:595.7 Insects
1, Thysanura; 2, Orthoptera; 3, Pseudo-Neuroptera; 4, Neuroptera; 5, Hemiptera; 6, Coleoptera; 7, Diptera; 8, Lepidoptera; 9, Hymenoptera

:596 Vertebrates

:597 Fishes

:597.6 Amphibians

:598.1 Reptiles

.2 Birds

:599 Mammals. Human, mostly to :61

578:6 The Microscope in Useful Arts

[Economic Microscopy]
Cf. 581.6 and 591.6

General. Div. like 578.01–.09

:6j The Microscope in Law

[Microscopical Jurisprudence]
Cf. Medical Microscopy, :61, especially Medical Jurisprudence, :614.23

:6j1 Courts; 3, Laws; 5, Evidence; 9, Fees

:6j2 Identification of Persons
Handwriting, Chirography, to :6j3

.1 Skin. 2, Hair. 3, Finger marks. 4, Clothing, etc.

.5 Blood stains. Identification, kinds

.8 Other stains

:6j3 Handwriting. Chirography

.1 Special Instruments and Technique

.2 Personal characteristics from

.21 Character of fingers or hand. Anatomical, pathological

.22 Temperament. .23, Tremor

.24 Habit. .25, Signature

.26 Position. Style

.27 Pen pressure. Shading

.28 Character and details of letters and words

Digitized by Google

578:6j3.29 Effects of excitement, fatigue, disease, age
.3 Disguised writing
.4 Pen characteristics
.5 Pencil characteristics
.6 Ink characteristics. Kinds, age, treatment
.7 Paper characteristics. Fibers, color, age, treatment
.8 Falsification. Forgery
1, Alterations
2, Additions; 4, Superposition; 6, Erasures; 8, Bleaching
.9 Imitative writing
.91 Tracing
.92 Mechanical effects; furrows, fibers
.93 Pencil marks; covered, uncovered, rubbed
.95 Off hand
:6j4 Counterfeiting. Cf. :76
:6j7 Sexual cases
1, Seminal stains; .2, Menstrual stains
.4 Impotence. .5, Sterility
.6 Divorce
.7 Rape
.8 Pregnancy. .9, Abortion
:6j8 Civil cases
Cases of actual or impending litigation, involving questions of identification or comparison, adulteration or falsification, qualities or values, age or wear, or other pecuniary interests, are often capable of receiving aid from the microscope
See Disputed writing, :6j3; Foods and beverages, :614.3; Hygiene and nuisances, :614.7; Drugs and poisons, :615; Textile and other Manufactures, :67; and other mercantile affairs in :658 or scattered through the various divisions from :62 to :69

Digitized by Google

'78:6j9 Criminal cases. Cf. Medical Jurisprudence, :614.23

.1 Forgery. Cf. :6j3.8

.2 Counterfeiting

.5 Poisoning. Cf. Micro-Chemistry, :54, and Poisons, :615.9

.6 Wounds

.63 Blood stains. Cf. :6j2.5

.65 Extraneous matters

.68 Powder grains and stains

3, Kind of weapon and ammunition

5, Distance of shot

:61 The Microscope in Medicine

[Medical Microscopy]

:016, Bibliography

0.1, Philosophy, Theories; .2, Compends, Treatises; .3, Dictionaries; .4, Essays, Addresses; .5, Periodicals; .6, Societies; .7, Educational; .72, Laboratories, Dissection, Experiments, Vivisection; .73, Bacteriology, to :583.3, or transferred here, if desired, for medical libraries; .74, Museums; .77, Teaching; .8, Collective works; .9, Medical History; .91, Medical Travels; .92, Medical Biographies

:611 Human Anatomy and Histology

This section parallels Comparative Anatomy, :591.4, and it is often preferable to combine the two, a medical specialist putting all here, and others putting all together in Zoology.

.012 Teratology

.013 Embryology

.013,11 Semen. ,15, Ovum

.013,3 Embryo. ,68, Blood. ,8, Adnexa

.018 Histology

1, The Cell; 2, Connective Tissue; 3, Cartilage; 4, Bone; 5, Blood; 6, Muscle; 7, Epithelium; 8, Nervous System; 81, Ganglia; 86, Nerves

Digitized by Google

578:611.1 Circulatory System
.2 Respiratory System
.3 Digestive System
.36, Liver; 7, Pancreas; 8, Peritoneum, Mesentery, Omentum
.4 Glandular and Lymphatic System
1, Spleen; 2, Vessels, ducts; 3, Thymus; 4, Thyroid; 5, Suprarenal gland; 6, Lymphatic glands
.6 Genito-Urinary System
1, Kidneys, ureters; 2, Bladder, urethra; 3, Testis, vas deferens, scrotum; 4, Penis; 5, Ovary, ducts; 6, Uterus; 7, Vagina, vulva; 9, Mammae
.7 Motor and Integumentary Organs
.77 Skin
.78 Hair. Nails
.8 Nervous System
.9 Regional Anatomy and Histology
:612 The Microscope in Physiology
:614 In Hygiene and Sanitation
.23 Medico-Legal Relations
Medical Jurisprudence will doubtless be put here most conveniently by most microscopists and physicians
.3 Adulterations, etc.
.31 Examination of Food
.32 Milk and Milk Products
.34 Beverages
.7 Impurities of Air and Ground
.71 Pollution and Injuries by Dust, Smoke, etc.
.78 Air in Country, Towns, Crowds, Parks, Roofs, etc.
.79 Air on Mountains, Snow-fields, Sea, Polar regions
:615 The Microscope in Pharmacy

Digitized by Google

578:615.9 Poisons

:616 The Microscope in Diseases. Pathology

.01 Etiology, Germ theory (general discussion only; details to Medical Bacteriology, :610.73, or with the special diseases); .07, Study, Diagnosis; .077, Clinical Microscopy

.1 Diseases of Circulatory System

.2 Respiratory System; .24, Lungs

.3 Digestive System

Diseases of teeth, to Dentistry, :617.6

.4 Lymphatic System. Div. like :611.4

.5 Skin Diseases. Dermatology

.6 Genito-Urinary System

Diseases of women, to :618

07, Urinary analysis

1, Kidneys, ducts; 2, Bladder,—calculus; 3, Urinary disorders,—diabetes; 4, Male urethra; 5, Prostate; 6, Penis; 7, Scrotum; 8, Spermatic cord, Testis; 9, Spermatorrhoea, Impotence, etc.

.7 Organs of Locomotion

.8 Nervous System

1, Cerebro-spinal circulation, Apoplexy; 2, Cerebro-spinal Meninges; 3, Structural of Brain and Cord; 5, Neuroses; 6, Special Neuroses, Alcoholism, etc.; 7, Diseases of nerves; 8, of Sympathetic system

.9 General Diseases

.91 Eruptive fevers

.92 Other fevers

3, Plague; 5, Cerebral-spinal; 7, Typhoid; 8, Yellow

.93 1, Diphtheria; 2, Cholera; 5, Dysentery; 6, Malarial

.94 Septic Diseases

.95 1, Syphilis; 2, Gonorrhoea; 3, Hydrophobia; 4, Glanders; 6, Splenic fever

Digitized by Google

578:616.96 Parasitic Diseases
.961 Animal Parasites. Cf. :595
.962 Entozoa
.968 Ectozoa; 1, Insects; 5, Arachnidans; 8, Suctoria
.969 Vegetable Parasites
.97 Poisoning. Cf. :615.9
.98 Effects of Injuries, Circumstances, etc. Mostly distributed elsewhere
.99 Other General Diseases
.991 Rheumatism. Gout
.992 Tumors
1, Modified connective tissue. Fatty, Fibrous, Cartilaginous, Bony, Mucous
3, Complex. Muscle, Nerve, Vessels, Glands, Warts
6, Embryonic type. Sarcoma
7, Epithelial, vascular. Carcinoma
9, Cysts
.995 Tubercle. 6, Scrofula. Rickets
.997 Myxoedema, etc. 8, Leprosy
:617 In Surgery
.6 Diseases of the Teeth. Dentistry
.7 Diseases of the Eye. Ophthalmology
.8 Diseases of the Ear
:618.1 In Gynecology
.2 Obstetrics
:619 In Veterinary Medicine
.1, Horses; .2, Cattle; .3, Sheep, Goats; .4, Swine; .5, Poultry; .6, Other Birds; .7, Dogs; .8, Cats; .9, Other animals

:62 The Microscope in Engineering

:620.1 Quality and strength of materials
.15 Effects of wear, stress, tremor, climate, etc.

:63 In Agriculture

:637 In the Dairy

Digitized by Google

578:64 In the Household
:65 In Communication and Commerce. Mercantile Affairs
:66 In Chemical Technology
:663.3 In the Brewery
:667 In Bleaching, Dyeing, etc.
:669 In Metallurgy and Assaying
:67 In Manufactures
:675 Leather and its Imitations
:676 Paper and other Pulp Products
.1 Rag-pulp. Kinds, qualities, condition
.2 Wood-pulp. Mechanical, chemical
.3 Other vegetable fibers. Straw, etc.
.5 Paper making
.6 Waterproofing, parchmentizing, etc.
.7 Built-up articles from paper
.8 Papier-maché
.9 Other Pulp-products
:677 Textile Industries
.01 Theories. Properties required for felting, spinning, cordage, weaving, etc.
.1 Vegetable Hairs. Cotton
.2 Fibers. Linen
.3 Hemp
.4 Other fibers and bundles
.6 Cordage
.6 Animal Hairs. Wool
.7 Others
.8 Silk
.88 Mercerizing, plating, etc.
.89 Artificial Silk
.9 Fibrous Minerals. Asbestos. Spun glass
:68 In Mechanic Trades
:69 In Building
:691.1 Wood, etc. Qualities, strength
Decay, Preservation
:7 In Art

Digitized by Google

Table of Geographic Subdivisions.

The following selection of a few of the place numbers of the decimal system will enable the microscopist to become familiar with this method of recording locality. Any of these numbers may be added to any index number. Ex., Rock sections from the Giant's Causeway, :552(415)

(2) Physical Geography Divisions

(21) Continents
Arctic regions, etc., to (98–9)
(212) Temperate regions
(213) Tropical regions
(22) Islands
(23) Mountains
(24) Caves
(25) Plains. Deserts
(26) Oceans. Seas [Oceanography]
(2601) Plankton
(261) North Atlantic
(2612) North Sea
(2613) Baltic
(262) Mediterranean
(2623) Adriatic
(2625) Black Sea
(263) Gulf of Mexico
(2635) Caribbean Sea
(264) South Atlantic
(265) Pacific
(266) East Pacific
(267) Indian Ocean
(2675) Red Sea
(268) Arctic Ocean
(269) Antarctic Ocean
(27) Ocean Currents
(28) Fresh Water
(2801) Fresh-water Plankton
(281) Streams
(285) Lakes
(29) Springs. Wells
(297) Stagnant water

Political Divisions

(4) Europe
(41) Scotland
(415) Ireland
(42) England
(429) Wales
(43) Germany
(436) Austria
(439) Hungary, etc.
(44) France
(45) Italy
(46) Spain
(469) Portugal
(4698) Madeira
(4699) Azores
(47) Russia
(48) Scandinavia. Denmark
(481) Norway
(485) Sweden
(489) Denmark
(49) Minor Countries
(491) Iceland

Digitized by Google

(492) Netherlands
(493) Belgium
(494) Switzerland
(495) Greece
(496) Turkey in Europe
(5) Asia
(51) China
(52) Japan
(53) Arabia
(54) India
(55) Persia
(56) Turkey in Asia
(57) Siberia
(58) Afghanistan, etc.
(59) Farther India
(6) Africa
(61) North Africa
(62) Egypt
(63) Abyssinia
(64) Morocco
(65) Algeria
(66) North Central Africa
(67) South Central Africa
(68) South Africa
(69) Madagascar
(7) North America
(71) Canada
(72) Mexico
(728) Central America
(729) West Indies
(73) United States
(74) No. Eastern States
(741) Maine
(742) New Hampshire
(743) Vermont
(744) Massachusetts
(745) Rhode Island
(746) Connecticut
(747) New York
(748) Pennsylvania
(749) New Jersey
(75) So. Eastern States
(751) Delaware
(752) Maryland
(753) Dist. of Columbia
(754) W. Virginia
(755) Virginia
(756) N. Carolina
(757) S. Carolina
(758) Georgia
(759) Florida
(76) So. Central States
(761) Alabama
(762) Mississippi
(763) Louisiana
(764) Texas
(765) Oklahoma
(766) Indian Territory
(767) Arkansas
(768) Tennessee
(769) Kentucky
(77) No. Central States
(771) Ohio
(772) Indiana
(773) Illinois
(774) Michigan
(775) Wisconsin
(776) Minnesota
(777) Iowa
(778) Missouri
(78) West Central States
(781) Kansas
(782) Nebraska
(783) So. Dakota

Digitized by Google

(784) No. Dakota
(786) Montana
(787) Wyoming
(788) Colorado
(789) New Mexico
(79) Pacific States
(791) Arizona
(792) Utah
(793) Nevada
(794) California
(795) Oregon
(796) Idaho
(797) Washington
(798) Alaska
(8) South America
(81) Brazil
(82) Argentine Republic
(829) Patagonia
(83) Chile
(84) Bolivia
(85) Peru
(86) Colombia
(866) Equador
(87) Venezuela
(88) Guiana
(89) Paraguay
(896) Uruguay
(9) Oceanica. Polar regions
(91) Malaysia
(914) Philippines
(92) Sunda
(921) Sumatra
(922) Java
(93) Australasia
(94) Australia
(95) New Guinea
(96) Polynesia
(961) Samoa, etc.
(967) Ladrones
(969) Hawaii
(97) Isolated islands
(98) Arctic regions
(99) Antarctic regions.

Digitized by Google

NEW GENERA AND SPECIES OF NORTH AMERICAN HYDRACHNIDAE.

By ROBERT H. WOLCOTT.

WITH PLATES IX–XII.

In collections made in different parts of Michigan in 1893, 1894 and 1895, were included a considerable number of specimens believed at the time to be not referable to any recognized genera. However, lack of literature made it then impossible to verify this supposition and since under these circumstances the writer was unwilling to assume the responsibility of erecting new genera to receive them, they were laid aside. Now he has at his command references to all genera hitherto described and it becomes possible to characterize with safety those which have not in the meantime been made known by others, for during the time which has elapsed the following genera, to which must be assigned a part of the specimens referred to, have been proposed:

Tyrrellia Koenike. (Koenike, 95b: 198.)
Krendowskia Piersig. (Piersig, 95a: 147.)
Limnesiopsis Piersig. (Piersig, 96: 20.)
Torrenticola Piersig. (Piersig, 97d: 155.)
Albia Thon. (Thon, 99: 100.)

Aside from these here enumerated, there remain three genera apparently still unnamed, and with these and also with one of those in the list above it is proposed in this paper to deal.

The technical expressions occurring in the paper are applied in the same manner and with the same meaning as indicated in a previous paper by the writer (Wolcott, 99:204) and need no explanation, except perhaps as to the mouth-parts, to the differ-

Digitized by Google

ent structures of which different authors have applied very different names. The whole irregularly conical mass formed by the mandibles and maxillae and the structures inclosed by them is termed the "snout" and in *Krendowskia*, where unusually protrusible, the "proboscis." The word "rostrum" is applied to the smaller cone at the apex of the snout, made up of the anterior portion of the maxillae, grooved for the passage of the mandibles, and leading to the oral opening at the anterior end. The "maxillary plate" or "maxillary shield" is the plate which forms the ventral surface of the snout, is generally more or less regularly shield-shaped, and fits in between the two anterior epimera. The rostrum appears from beneath as a median anterior projection of this plate.

The divisions of the family Hydrachnidae as recognized by Piersig and used in his great work on German Hydrachnidae (Piersig, 97), are accepted by the writer.

KRENDOWSKIA (Piersig).

Krendowskia Piersig, 95a: 147.

Geayia Thor, 97b: 11.

Diagnosis of genus: An hydrachnid of the sub-family Hygrobatinae, with broadly oval body covered throughout with a thick chitinous exoskeleton containing large goblet-shaped pores, and divided into a larger ventral and a smaller dorsal portion by a continuous suture; with epimera forming four masses; with stout chelate palpi and mouth-parts borne at the end of a protrusible proboscis; with legs bearing swimming-hairs; and with the large genital opening situated between the two posterior epimera and flanked on either side by a large valve which bears on its face three or four acetabula and along its margin a row of minute hairs.

The genus is most closely related to *Arrenurus*, which it resembles in the character of its chitinous exoskeleton, in the form of its palpi, in the arrangement of its epimera, and in the possession of swimming-hairs. It is, however, at once recognized by the character of the genital area, which reminds one

Digitized by Google

of *Mideopsis*, and by the protrusible proboscis which is quite unique among these mites. The males also possess none of the modifications of form and structure characteristic of the males of *Arrenurus*.

This genus was unknown until, in 1885, Krendowsky described and figured as the female of *Arrenurus punctator* Koch, a mite which Piersig recognized as belonging to a new genus and species and to which he gave the name *Krendowskia latissima*. However, the proposed name was not accompanied by any characterization of the genus or description of the species and, though glad to accept the name, which is a well-deserved recognition of the work of the only prominent Russian student of this group, the author cannot refrain from expressing his dislike of the manner in which the genus was proposed. He would not thus venture to criticize one whose recent magnificent work has made him a recognized authority on the group, did he not feel that the bestowal of generic names in the way indicated was based on a principle radically wrong, It should be required of every author of a genus that in the place where it is proposed he give such a generic diagnosis as will clearly define its essential characters, if no more. Especially is the lack of such a diagnosis to be regretted when the original reference is difficult of access or of use by the majority of students.

The genus *Geayia*, proposed by Thor to include *Geayia Venezuelae*, a species collected in Venezuela by a traveller, M. Geay, seems undoubtedly identical with *Krendowskia*, which antedates it by two years.

An approximate translation of Krendowsky's original description (Krendowsky, 85: 116) is as follows:

"6. *Arrenurus punctator* Koch (Tab. VII, Fig. 11).
Deut. Crust. H. 12. 10.

Female—Body oval, convex dorsally, narrower anteriorly, but not excavated in front, and of a pale green color with dark dorsal patches. Chitinous layer of the cuticula containing tortuous pores which anastomose at their inner ends and open externally into cup-shaped depressions. Epimera green; forming

Digitized by Google

four groups, and in shape differing from those of the different species of *Arrenurus* in the fact that they have rounded outer margins, and do not end in sharp points. The fourth pair has also a marked peculiarity, being produced posteriorly, this posterior portion quadrate in form with rounded corners. Between these two epimera is placed the large genital area which is approximately circular in form. The large round genital opening is closed by two semi-lunar genital plates with wavy outer margins. Along the margin of each plate are placed three narrow elliptical acetabula. Legs of medium length and green in color.

The form is very rare. Only one example was found, August 5th, in the Psel, near the village of Manuilowka, county of Kremenchuk, province of Poltawa.

Male unknown to me."

Thor (97b: 11) describes *Geayia* thus:

"*Geayia*, nov. gen.

Le corps et les pattes, dans ce nouveau genre, sont tout à fait semblables à ceux de *Arrenurus* Dugès. La peau est très dure, avec beaucoup de pores et une ligne dorsale. Les pattes sont courtes et minces, pourvues de soies natatoires.

L'appareil génital, au contraire, rappelle celui de *Mideopsis*, Neum.; il est elliptique et situé entre les épimères de la quatrième paire. De chaque côté de la frente génitale se trouvent quatre ventouses ou pores oblongues, insérées sur les deux valves semilunaires. On trouve quelques pores (fig. 2) très petits disposés en cercle dans la peau, en dehors des valves.

Le plus caractéristique pour *Geayia* est un *rostre énormément long*, paraissant formé de deux articles et d'une forme tout à fait inconnue chez les Hydrachnides adultes.

Il rappelle un peu celui de *Nautarachna* Moniez, moins celui de *Hydryphantes* Koch, *Hydrachna* Müller, etc. Les deux courts palpes sont, fait remarquable, attachés à son extrémité.

Le rostre provient d'un court tube de la peau (tube labial) il forme en dehors du tube deux articles à peu près de même longueur, le second s'élevant à l'extrémité proéminente et un

Digitized by Google

peu recourbée du premier. Dans le second sont les courtes mandibules, et d'une échancrure du côté superiéur s'élèvent les deux courts palpes formant comme une pince avec le bord inférieur proéminent du rostre.

Chaque palpe a les cinq articles, le premier se cachant, le cinquième ressemblant à un petit crochet, semblable à celui d'*Arrenurus*, et s'articulant avec une protubérance plate du quatrième."

Comparison of the one male specimen in the possession of the writer with Krendowsky's figure and description leaves little room to doubt that that author had a male specimen, which he assumed was a female because of the lack of the usual characters which distinguish the males of *Arrenurus*; while the three female specimens examined belong to the same genus as those described by Thor, and to a species at least closely allied. Krendowsky failed to note the protrusible proboscis, but in the brief examination to which the mites under observation were subjected by the writer, when collected and before being put into the preserving fluid, no such peculiarity was noted in either sex, and it is probable that in the case of Krendowsky's specimen the methods used were such as failed to demonstrate it. Krendowsky's specimen had three pairs of acetabula, Thor's examples four, but this is apparently a sexual character.

It may be simply a matter of individual opinion, but to the writer the dedication of a genus to one neither a student of the group to which it belongs nor prominent for his contributions to the literature of the science of zoology in general seems quite inappropriate.

Krendowskia is a genus of wide distribution, as is shown by its occurrence in localities as widely separated as Russia, Venezuela, and Michigan.

Krendowskia ovata nov. sp.

General form (Pl. IX, Fig. 1) broadly oval, the length exceeding the maximum breadth by but about one-tenth, with the more pointed end directed anteriorly, uniformly rounded at both ends, strongly convex dorsally, moderately convex ven-

Digitized by Google

trally, and with the dorso-ventral diameter of the body equalling nearly three-fourths of the total length.

Surface of the body covered with a chitinous exoskeleton containing pores placed vertically to the surface. These pores (Pl. IX, Fig. 2) are large, usually more or less irregular in diameter and in direction, are similar to those figured by Nordenskiöld (98: Pl. I, Fig. 3a) for *Arrenurus pustulator*, and give to the body the appearance of being coarsely pitted. The cuticula which covers this chitinous exoskeleton is marked everywhere by irregular fine wavy lines. The furrow which separates the smaller dorsal and the larger ventral portions of the exoskeleton includes an elliptical area, which is, in a male specimen 1 mm. long, 0.835 mm. by 0.651 mm., and which approaches nearer the posterior than the anterior end of the body. Here and there on the dorsal surface (Pl. IX, Figs. 1 and 3) are seen rounded papillae bearing slender hairs.

Eyes rather close together, large, and separated by a distance equal to one-fifth the length of the body.

Proboscis protrusible to a distance equal to 65 per cent. of the body length (Pl. IX, Fig. 3) and divisible into two portions. The posterior of these is soft, capable of being inverted, equal to three-fifths the length of the whole, and thickest proximally while narrowest at its distal end. The anterior, consisting of the mouth-parts, is covered by the chitinous maxillae, is thickest distally, where its breadth is equal to two-thirds the greatest breadth of the posterior portion, and narrowest at its junction with the posterior portion. The anterior ventral angle is produced forming a rostrum the tip of which is even with the end of the palpi and which near its tip bears two small hairs.

Mandibles (Pl. IX, Figs. 4 and 5) long, irregular and ending in a double claw. On the inner side is what appears to be an articular suture but which is not apparent on the outer side.

Palpi (Pl. IX, Fig. 6) relatively small and stout, the average thickness being equal to more than one-quarter of the total length, and chelate like those of *Arrenurus*. Segments 1 to 4 nearly the same in dorso-ventral diameter and 1 and 2 together

Digitized by Google

equailing the combined length of 3 and 4. Segment 1 is long and forms a ring of uniform width; 2 is the longest and possesses a long convex dorsal margin and a short concave ventral margin, the difference in length of the two causing the two ends to lie nearly at a right angle to one another. The latter possesses two long slender hairs, one on the dorsal margin and another on the inner surface and near the second a third short hair. Segment 3 is comparatively short with the dorsal and ventral margins nearly equal, and bears a hair on the inner surface toward the dorsal margin; while 4 is nearly as long as 2, is thick, and is, toward the tip and on the ventral side, expanded and also produced to a considerable degree. This expanded portion bears a slender hair and another is situated at the distal end of the dorsal margin. The distal segment is short and stout, bears a peg-like spine at the tip, and is opposable with the produced ventral expansion of 4, giving to the palpus its chelate character.

The epimera (Pl. IX, Fig. 7) occupy somewhat more than the anterior half of the ventral surface and are divisible into four groups. Epimera I and II of each side are approximated and also united across the median line, while III and IV of each side are also approximated but separated from those of the opposite side and from I and II of the same side by a considerable interval. The outline of the individual epimera is shown in Pl. IX, Fig. 7. There is little difference in size between I, II and III and all are roughly triangular; while IV is much larger and characteristic in form. The latter meets III by an anterior margin equal to two-thirds the length of the posterior margin of III; the inner margin is excavated anteriorly and is then continuous with the rounded posterior margin which in turn merges into the outer margin so that the epimeron becomes quite evenly rounded posteriorly. The outer margin of the same epimeron is produced antero-laterally and at this point leg IV is attached. Epimera III bears a long slender hair towards its inner end and opening in the excavation in the inner margin of IV is what is apparently a large gland, while toward the median line from this are two long slender hairs.

Digitized by Google

Legs rather short, only the last pair exceeding the body in length, and the first only two-thirds the length of the body. Legs II and III nearly the same length, though III is slightly the longer. On the whole the legs are rather slender and the segments decrease uniformly in length from the outer end to the base except that in leg III, 5 exceeds 6 and in IV both 5 and 4 exceed 6, 5 being longer than 4. Legs I and II bear numerous long slender spines and hairs; III possesses a cluster of slender hairs on 4 and 5, and one or two serrate spines on 2 and a clump of slender hairs at the distal end of each of segments 3, 4 and 5. There are also at the tip of each of these three segments a few very prominent serrate spines; and 4, 5 and 6 are also characterized by a row of spines on the flexor surface. The claws are retractile, evenly curved, sharply pointed, and possess an accessory claw on the convex margin close to the tip.

The genital area (Pl. IX, Fig. 7) is included for somewhat over one-half its length between the two posterior epimera and is nearly as broad as long, while its length equals about three-tenths the total length of the body. The opening is guarded by two valves each of which bears on its face next the margin elliptical acetabula, in the male three in number, in the female four. Along its thickened margin is also seen a row of about a dozen small spines. How complete the possibility of closure of these valves may be is not apparent from the specimens.

MEASUREMENTS OF A FEMALE SPECIMEN:

Length of body	0.924 mm.
Length of palpus	0.148 mm.
Length of mandible	0.265 mm.
Length of leg I	0.612 mm.
Length of leg II	0.780 mm.
Length of leg III	0.826 mm.
Length of leg IV	0.964 mm.
Length of genital area	0.281 mm.

The male and female differ but slightly from one another, the most prominent sexual character being the difference in the number of genital acetabula.

Types retained in the author's collection.

Digitized by Google

Three specimens were collected in Power's Lake, Grand Rapids, Michigan, August 9, 1895, and one in Crooked Lake, Grand Rapids, Michigan, August 19, 1895. The color of the three former specimens as given in field notes taken at the time was "dark rich brown dotted with blackish, legs dull greenish," while the specimen from Crooked Lake is noted as being "dark blue green."

The indefiniteness in regard to certain details in the description of both Krendowsky and Thor makes it impossible to decide with certainty whether or not this species is identical with that obtained by either one of the other two writers. However, the form of the posterior epimera, as well as the general form of body given in Krendowsky's figure, is not quite the same as in the American specimens, the body being proportionately broader while the epimera referred to do not stop short of the inner end of the pair in front, but are prolonged toward the median line to a point even with the inner ends of this pair and this prolongation is at its end even wider than the inner end of the third pair. In Thor's examples the palpi are relatively smaller, while in his description he also says "La ligne dorsale est presque circulaire ou ovale," whereas in the writer's specimens the area enclosed by this line is elliptical. In Thor's figure (Fig. 4) this area is a very pointed oval.

On the whole we prefer to describe our specimens as belonging to a distinct species believing that these differences, together with the wide separation of Michigan from the localities in which the others were found, render it probable that such is the case.

The significance of the specific name is at once apparent from the outline of the body.

Xystonotus nov. gen.

Diagnosis of genus: An hydrachnid of the sub-family Hygrobatinae, with elliptical body flattened dorso-ventrally, covered by a chitinous exoskeleton which is separated into smaller dorsal and larger ventral portions by a continuous furrow and is

Digitized by Google

pierced by numerous fine canals which pursue an irregular course and tend to branch and anastomose; with epimera all fused to form a single plate; with legs without swimming-hairs; and with a genital area large and pyriform and the opening guarded by two valves, on the inner surface of which are three pairs of acetabula.

This genus is, in the character of the genital area and in the possession of three pairs of acetabula, and also in the general form of the body related to *Mideopsis*, but differs in the lack of swimming-hairs and in the relatively longer palpi and in the form of the epimera. The claws are similar to those figured by Piersig for *Midea* in having a sharply pointed and longer tip on the convex side and on the concave a shorter tip slightly curved and spatulate in form. However, the genus differs more widely from *Midea* than from *Mideopsis* in the character of the palpi, of the genital area, of the epimera, and also in the lack of swimming-hairs.

The generic name is derived from the Greek words *xystos*, smoothed as with a plane, and *notos*, the dorsum or back, and is bestowed in allusion to the very characteristic form of the single species here described as belonging to the genus.

Xystonotus asper nov. sp.

Body (Pl. X, Fig. 8) of medium size and with a width about equal to five-sixths the length, elliptical, evenly rounded posteriorly and somewhat flattened but hardly excavated at the anterior end; compressed dorso-ventrally and more convex below than above, the dorsal surface being nearly plane with but a slight antero-posterior convexity, and meeting the lateral body wall at about a right angle. The body is furnished with a few short spines, with two longer ones at the anterior end between the eyes, and with a bunch of three still longer, on either side of the posterior end of the body. The chitinous exoskeleton is very thick, covered by a thin cuticula showing here and there fine irregular lines, and is perforated by numerous branching canals (Pl. X, Fig. 9) which tend to anastomose and which give almost a dendritic appearance.

Digitized by Google

Eyes rather wide apart, separated by a distance equal to about three-tenths of the total length of the body and of moderate size.

Maxillary shield rather narrow, with nearly parallel sides, a rounded posterior margin, and an acute though not very prominent rostrum.

Mandibles (Pl. X, Fig. 10) rather small, their total length being between one-fifth and one-sixth the length of the body, moderately stout, irregular, and bearing a very large, tapering and pointed claw.

Palpi (Pl. X, Fig. 11) irregular in general form, with segment 2 widest, and the succeeding ones tapering from 3 to 5. The length of the palpus is equal to one-fourth the length of the body and its maximum thickness to two-sevenths of its total length. The first segment is very slender and possesses a spine on the dorsal margin, while segment 2 is much thicker than 1 and thickest of all, is quadrate in form, and bears three stout spines along the dorsal margin, two posterior ones side by side and a third distad of them. Segment 3 is rather short, bears a spine toward the distal end and another at the dorsal margin; 4 tapers from base to tip, has a slightly convex and somewhat irregular dorsal margin and a ventral margin produced in its proximal portion into a beak-like process the tip of which is directed inward with respect to the palpus, bears two small spines and ends in a sharp, somewhat recurved, point. The distal segment tapers gradually from base to tip where it is blunt and terminated by three points.

The epimera (Pl. X, Fig. 12) are united forming one plate which however shows clearly the lines of separation between the separate epimera. Of these epimera I and II are long, narrow, and roughly triangular; III is long and quadrilateral in form; IV again roughly triangular with the three margins nearly equal and with the inner angle rounded. The posterior margin of this fourth pair is not clearly defined but passes over into the surface of the body. The epimeral plate is pierced by pores similar to those which open over the surface of the body,

Digitized by Google

and upon focussing these pores are seen to lead to branched canals passing through the epimeral plate. Glands open between the first and second and second and third epimera.

The legs (Pl. X, Fig. 12) are rather short and stout, none of them possessing swimming-hairs but all short, stout spines, and all have the individual segments produced distally and the last segment expanded at the tip. The outer margin of each segment is also more or less dentate, this peculiarity being more pronounced in the hind leg than in the fore leg, while in the hind leg the spines tend to group themselves about the tips of the segments. The fourth pair of legs also possesses on segments 5 and 6 a row of spines along the flexor margin. Of the individual legs the first is the shortest and less than four-sevenths the length of the body; II is nearly two-thirds as long as the body; III about four-fifths its length. while IV exceeds it by one-eighth. The length of the individual segments is in each leg, in order, beginning with the shortest, 1, 2, 3, 4, 5, 6. 1, 2, 3, and 4 are nearly equal in I and II, 3 is shortened and only equals 1 in III, and 4 is longer than the other two in IV.

The claws (Pl. X, Fig. 14) possess two tips, a slender strongly curved and sharply pointed dorsal tip and ventrad of this a shorter tip which is but slightly curved and flat and spatulate in form.

Genital area (Pl. X, Fig. 12) situated toward the posterior end of the body and pyriform, while owing to the fact that the genital cleft is shorter than the extreme length of either of the two plates which bound it there is a narrow indentation anteriorly in the median line. The total breadth is even greater than the length. In addition to these two plates set immovably into the wall of the body there are two valves, narrower than the plates, each of which bears near the margin of its inner face three long narrow acetabula in a row one behind the other. Between the genital area and the fourth epimeron of either side is the large opening of a gland.

The anal opening is situated midway between the genital opening and the posterior extremity of the body.

Digitized by Google

MEASUREMENTS:

Length of body, female	0.610 mm.
Width of body, female	0.493 mm.
Palpus, total length	0.148 mm.
Mandible, total length	0.112 mm.
Leg I, (exclusive of claw)	0.337 mm.
Leg II, " " "	0.393 mm.
Leg III, " " "	0.490 mm.
Leg IV, " " "	0.678 mm.
Length of genital cleft	0.127 mm.
Extreme breadth of genital area	0.143 mm.

Of this species only two specimens were obtained, from Lake Saint Clair during August, 1893. Both are apparently females, from the fact that an egg is seen within the body of one, and no males have come under the writer's observation. The types are preserved in his collection.

The specific name is suggested by the rough appearance of the animal as a whole and the generally irregular outline of the appendages.

KOENIKEA nov. gen.

Diagnosis of genus: An hydrachnid of the sub-family Hygrobatinae with body greatly compressed and even concave on the dorsal surface, covered by a thick chitinous exoskeleton pierced by fine pores parallel to one another and vertical to the surface; with the antero-inferior angles of the maxillae in the female produced to form a long curved rostrum; with the epimera in the male fused forming a single plate, in the female forming a plate on either side; with legs bearing swimming-hairs; and with the genital cleft flanked by two large valves and numerous acetabula imbedded in the wall of the body.

This genus belongs, with the next, among those which in Piersig's arrangement immediately precede *Arrenurus* and which include *Axonopsis* Piersig, *Albia* Thon, *Aturus* Kramer, *Torrenticola* Piersig, *Mideopsis* Neuman, *Midea* Bruzelius, and *Xystonotus* mihi. It is, however, peculiar in the form of the body, in the character of the genital area, and, in the case of the female, in the possession of a long rostrum. This latter

Digitized by Google

structure, which will be more fully described in connection with the description of the species, is, in the male, similar to that figured by Piersig for *Mideopsis*, but in the female is unlike any structure hitherto described, although *Torrenticola* shows a tendency to the production of the rostrum in a somewhat similar manner. From *Aturus*, *Torrenticola*, *and Xystonotus*, this genus may be at once distinguished by the presence of swimming-hairs; from *Mideopsis*, *Midea*, *Albia*, *and Axonopsis* it is easily distinguished by the character of the epimera and genital area. The author takes great pleasure in dedicating this characteristic and attractive genus to Dr. Ferdinand Koenike of Bremen, Germany, whose name is perhaps the most prominent of all among students of the group owing to the length of time he has devoted to the subject, the number of his writings, and the numerous and valuable additions he has made through them to our knowledge of the subject.

Koenikea concava nov. sp.

Of medium size, the males averaging about 0.62 mm., the females from 0.72 to 0.75 mm. As seen from above (Pl. XI, Fig. 15) nearly circular in outline, being but slightly longer than broad, and with a slight excavation between the eyes which is rendered more apparent by the projection of the latter from the body; viewed from the side, however, the mite is seen to be greatly flattened, convex below, and even concave above. There is a slight antero-posterior convexity but the concavity is more marked and thus is formed a sharp rim extending entirely around the margin. The dorsal portion of the exoskeletal covering is the smaller and the furrow separating it from the ventral forms a nearly circular outline parallel to the margin of body, from which it is separated by a moderate interval. This exoskeleton is pierced by numerous fine pores (Pl. XI, Fig. 16) parallel to one another and vertical to the surface and is covered by a thin structureless cuticula. The body is also marked by more prominent pores, which probably represent the openings of glands, and bears several hairs arising from papillae below and in front of the eyes and two hairs at the posterior margin of the body.

Digitized by Google

Eyes a moderate distance apart, the interval between them a little less than one-third the length of the body, black and prominent.

The rostrum of the male (Pl. XI, Fig. 17) is moderately prolonged, the lower margin to a greater extent than the upper causing the oral opening to look upward as well as forward. The lower margin of the rostrum of the female (Pl. XI, Fig. 18) is greatly elongated and forms a long upwardly curved spine bearing a dorsal median groove which ends just before the tip. This rostral spine at its base equals in thickness one-fourth the maximum dorso-ventral diameter of the snout, tapers very gradually to a bluntly rounded tip and has a total length, measured along its axis, about equal to the rest of the snout. In the groove on the dorsal side of the rostrum runs the elongated distal segments of the mandibles. This mandibular "claw" are attached to the ventral side of the basal segment of the mandible close to the tip (Pl. XI, Fig. 21), and is remarkably slender while the basal segment is not specially noteworthy, having about the usual form with a concave ventral and convex dorsal margin and a rounded posterior extremity.

Palpi (Pl. XI, Fig. 19) weak in proportion to the size of the body, equalling in the male only three-tenths of the body length, and also unusually slender, having a maximum breadth equal to only one-sixth the total length; even weaker in the female than in the male. Segment 2 the stoutest, yet but little stouter than 1, and those beyond gradually becoming more slender to the tip. Segment 2 bears two spines on the extensor surface and 3 a long slender hair on the extensor surface and another on the inner surface; 4 a slender hair on the outer surface and on the flexor surface nearly at the tip a short papilla tipped by a very small spine. The distal segment bears a small dorsal claw-like spine a little back from the tip, a stouter median spine somewhat further toward the tip, and these, together with the narrowed ventral tip, gives the segment the appearance of ending in three points.

The epimera in the male (Pl. XII, Fig. 23) are united into one plate which is pierced by pores similar to those over the rest of

Digitized by Google

the surface of the body and in which the limits of the separate epimera are indicated by denser, more highly refractive, broad strips of chitin. In the female (Pl. XII, Fig. 24) the epimera form two masses, one on either side, and a narrower interval separates the two anterior of the opposite sides, while a broad space intervenes between III and IV of the opposite sides. The inner ends of II and III of each side are separate, forming a wide angle. The outline of the whole epimeral area is irregular, with rounded angles, considerably emarginate between the places of attachment of the legs and with a shallow concavity in the median line posteriorly which is limited externally by rounded angles in the middle of the hind margin of epimera IV.

Legs of the male rather short, I only three-fourths of the body length, II nine-tenths as long as the body, III still nearer the length of the body, and IV nearly one-tenth longer. In the female the legs are relatively longer, I being six-sevenths and II over nine-tenths the body length, while III is a little longer than the body, and IV exceeds it by one-fifth. Of individual segments the distal is the longest and the rest decrease in length in order toward the base, except that 2 exceeds 3 in all cases with the exception of leg IV of the female. The legs are rather slender and rather sparingly supplied with slender spines and swimming-hairs, the latter being found on segments III 5, IV 4, and IV 5. At the tip of III 4, there is also a stout serrated spine, and on IV 3 one, and on IV 4 and IV 5 two each (Pl. XI, Fig. 20); the serrated spines in each case are in line, being the most distal of a row of blunt spines on the flexor margin of the segment. In the male the spines are fewer and the legs slenderer than in the female.

In the case of both male and female the genital cleft (Pl. XII, Fig. 24) is long, equaling one-fifth the total length of the body, and is flanked by two large movable chitinous valves which together form a broadly pyriform area of considerable size. On either side outside of these valves and opposite their posterior portion are about twenty small acetabula imbedded in the body wall, while between the anterior portion of these valves and

Digitized by Google

the posterior epimera are what appear to be the openings of two large glands, and just external to these two long hairs.

The anal opening is situated at the posterior end of the body and on either side of it are two hairs.

MEASUREMENTS:

	Male	Female
Length of body	0.618 mm.	0.685 mm.
Breadth of body	0.584 mm.	0.618 mm.
Length of leg I	0.464 mm.	0.571 mm.
Length of leg II	0.566 mm.	0.637 mm.
Length of leg III	0.597 mm.	0.719 mm.
Length of leg IV	0.663 mm.	0.836 mm.
Length of palpus (approximate)	0.190 mm.	0.210 mm.
Length of genital groove	0.122 mm.	0.143 mm.
Extreme breadth of genital valves.	0.117 mm.	0.133 mm.

The types are retained in the author's collection; co-types will be deposited in the collection of the Zoological Department, University of Nebraska, in the Museum of Comparative Zoology of Harvard University, in the United States National Museum, and in the Kgl. Museum für Naturkunde in Berlin.

Numerous specimens of this species were secured in Lake Saint Clair, Michigan, during August and September of 1893; in Susan and "26" Lakes, Northern Michigan, in August, 1894; and in Reed's, Fisk's, Lamberton, Powers', and Dean's Lakes, near Grand Rapids, Michigan, in July and August, 1895. It thus seems to be a common and widely spread species, at least in Michigan.

The name is bestowed in reference to the very characteristic form of the body, the dorsal surface of which is strikingly concave.

Tanaognathus nov. gen.

Diagnosis of genus; An hydrachnid of the sub-family Hygrobatinae, with body compressed dorso-ventrally and covered by a very thin exoskeleton consisting of a network of chitinous trabeculae, and divided into a smaller dorsal and a but slightly larger ventral portion by a continuous suture; with the rostrum of the female(?) produced as in the female of *Koenikea*, and with

Digitized by Google

the epimera similar to those of that genus; with the distal end of the fourth segment of the palpus bearing a nipple-like process, extended parallel to the distal segment; with the legs bearing a few swimming-hairs; and with the genital cleft short, unguarded by valves or plates of any kind, and with the numerous acetabula imbedded in the wall of the body.

This genus is described from only one specimen, the sex of which it is impossible to determine owing to the manner of preservation, which has not been such as to preserve the internal structure. The marked resemblance of the specimen to the females of *Koenikea* renders it probable that it is a female of a closely allied genus and, at the same time, serves to distinguish it, with *Koenikea*, from all other genera.

The author recognizes the danger of establishing a genus under the circumstances, but is forced either to assign the species to the genus *Koenikea* or to establish a new genus to receive it, and believes that the very marked difference in the character of the chitinous exoskeleton, the characteristic form of the palpi, the absence of any valves or plates guarding the genital cleft, and also the peculiar form of the claw of the first leg, which is quite unique among the forms hitherto described, and which suggests that the specimen may be after all a male, are of sufficient weight to justify the placing of it in a different genus.

The name is derived from the Greek *tanaos*, long, and *gnathos*, a jaw, an allusion to the elongated rostrum, which is a marked peculiarity of this genus, although a peculiarity shared by the genus previously described.

Tanaognathus spinipes nov. sp.

The specimen which is here described is 0.668 mm. in length and almost precisely the same in maximum breadth, the outline of the body being thus circular. It is considerably compressed dorso-ventrally and with a very slightly convex and quite uneven dorsal surface and a more convex ventral surface. The body is covered by a very thin chitinous exoskeleton, the pores of which are so large that it is apparently made up of a fine network of chitinous trabeculae; outside of this is a cuticula marked

Digitized by Google

by fine, wavy, parallel striae. In front of the eye and external to it is a papilla bearing a small hair, and toward the median line are two more, the one nearest the median line being the larger. A furrow, which is very close to the margin on the dorsal side thus making the ventral portion but slightly the larger, separates the dorsal from the ventral portion of the exoskeleton.

The eyes are large and rather wide apart, the distance between them being 0.284 mm.

The mouth parts (Pl. XII, Fig. 25) bear a very close resemblance to those of *Koenikea concava* and can best be described by a direct comparison with those of that species. The dorsal surface of the snout is less convex, and the ventral is not only less convex but is also almost continuous with the lower surface of the projecting rostrum instead of there being a considerable angle between them. The snout is, therefore, proportionately longer in the species under consideration while, it may be added, the palpi and rostrum are in proportion noticeably shorter. Two long, relatively stout hairs arise from the vertex between the palpi and run downward toward the rostrum, then turning forward are applied to its dorsal surface. As above indicated, the rostrum appears to arise from the anterior end of the snout at the ventral margin, and runs forward curving gradually upward, whereas in *Koenikea* the rostrum appears to come from the middle of the anterior end of the snout and forms a right angle with the surface ventrad of its base.

The palpi (Pl. XI, Fig. 22) are markedly different from those of *Koenikea concava* and very characteristic. On the slide neither one of the two lies in the best position for observation, but it is evident that the palpi are relatively short, that the basal segment is unusually stout, exceeding considerably in breadth any of the rest, and that the rest gradually decrease in thickness to the tip. Owing to foreshortening the exact relative length of the segments cannot be told, but 3 is certainly much longer and 4 much shorter than usual. Segment 2 bears a small hair in the middle of the extensor surface; segment 4

Digitized by Google

not only receives at its tip segment 5, but internally to the articulation with 5 the segment is produced into a nipple-like papilla projecting parallel to 5 to a distance equal to one-third the length of the distal segment. At the base of this papilla and on the internal surface of the segment is a small hair, while on the inner side of 5 is also a small hair. Segment 5 ends in a blunt tip which shows, in a very inconspicuous manner, the presence of three chitinous claws.

The outlines of the different epimera (Pl. XII, Fig. 26) are distinct but all the epimera meet one another except for a very narrow interval between the anterior pair and an open space at the angle between I, II and III. The outline of the whole epimeral field is similar to that of the male of *Koenikea concava*, but the external margin of IV is more produced and the angle on the posterior margin of the same epimeron is sharper.

The legs are relatively stout, the first unusually long and the last proportionately shorter. The measurements of the legs are as follows: I, 0.704 mm.; II, 0.770 mm.; III, 0.775 mm.; IV, 0.816 mm. The segments in each of the legs are, in order of length, beginning with the longest, 5, 6, 4, 2, 3, 1. In each leg segment 5 is swollen at the middle and possesses a convex extensor margin, while segment 6 is curved toward the tip, the extensor margin being convex, the flexor concave. Of the individual legs, I is the stoutest and its claw (Pl. XII, Fig. 28) is peculiar, being very long, slender, and extending straight out beyond the tip of segment 6 to a distance equal to one-half the length of that segment. There is a stout serrate spine at the tip of segment 5 on the ventral side. Segment II 5 also bears a similar serrate spine and the claw of II 6, like that of the rest of the legs, is small, simple, and evenly curved. Leg III is similar to leg II, while IV is noteworthy. This last leg (Pl. XII, Fig. 27) possesses two serrate spines, one beyond the other on the flexor surface of segment 3, five in a row on 4, and a row of six on 5, while a single long swimming-hair is borne at the tip of 3, two at the tip of 4 and three at the tip of 5.

Digitized by Google

The genital cleft (Pl. XII, Fig. 26) is very short, being only 0.071 mm. long, and is unguarded by valves or plates of any kind. On either side and occupying a field semicircular in outline with the straight side antero-lateral are about forty-five acetabula imbedded in the wall of the body. On either side just laterad of the posterior end of the genital cleft is a small hair, behind which is a long slender one, and still further posteriad another small one.

Anal opening toward the posterior margin of the body.

The single specimen observed was taken from Soft-water Lake, Grand Rapids, Michigan, August 19, 1895, and in field notes made at the time the color is described as of a bright red with greenish blue legs. This type specimen is retained in the author's collection.

The name is suggested at once by the character of the legs.

Zoological Laboratory,
The University of Nebraska.

Digitized by Google

LITERATURE.*

KOENIKE, F.

95b. Nordamerikanische Hydrachniden. Abh. des. naturwiss. Ver. zu Bremen; XIII (1895), 167-226, Pls. I–III. Also separate: Bremen, 1895.

KRENDOWSKY, M. E.

85. [The Fresh-water Mites of Southern Russia.] (Russian.) [Contributions from the Society of Naturalists at the Imperial University of Kharkow]; XVIII (1884), 209-358, Pls. VII, VIII. Separate: Kharkow, 1885.

NORDENSKIÖLD, ERIK.

98. Beiträge zur Kenntnis der Morphologie und Systematik der Hydrachniden. Acta Soc. Scient. Fennicae; XXIV (1898), 1-75, Pls. I, II. Helsingfors, 1898.

PIERSIG, R.

95a. Einiges über die Hydrachniden-Gattungen "Arrenurus" Dugès und "Thyas" C. L. Koch. Zool. Anz.; XVIII (1895), 138-140, 145-148; 3 Figs.

96. Beiträge zur Kenntnis der in Sachsen einheimischen Hydrachniden-Formen. Inaug.-Dissert. 71 pp. Leipzig, 1896.

97. Deutschlands Hydrachniden. Bibliotheca Zoologica, XXII. VII+ 601 pp., Pls. I–LI. Stuttgart, 1897-1900.

97d. Eine neue Hydrachniden-Gattung. Sitzungsber. Naturf. Ges. Leipzig; XXII, XXIII (1895-96), 155-157. (June 15, 1897.)

THON, KARL.

99. Ein neues Hydrachnidengenus aus Böhmen, nebst einigen Bemerkungen über böhmische Hydryphantes-Formen. Zool. Anz.; XXII (1899), 100-102.

THOR, SIG.

97b. Une intéressante Hydrachnide nouvelle, provenant des récoltes de M. Geay au Vénézuela. Bull. Mus. d'hist. nat.; (1897), 11-13, Figs. 1-6.

WOLCOTT, R. H.

99. On the North American Species of the Genus Atax (Fabr.) Bruz. Studies from the Zool. Lab. Univ. of Nebr., No. 80. Trans. Am. Micros. Soc.; XX (1898), 193-259, Pls. XXVIII–XXXII. (May, 1899.)

* The designation of each reference must be for the reader an arbitrary one, but is that used by the author in his card catalogue which he feels sure is practically complete for the Hydrachnidae and where it has been carefully chosen to indicate the sequence of publication, and is retained here to secure perfect uniformity in citation in this and other articles contributed by him.

Digitized by Google

EXPLANATION OF PLATES.

All figures drawn with the aid of a camera lucida.

PLATE IX.

All Figures of *Krendowskia ovata* nov. sp.

Fig. 1. Dorsal view of body of male. X 60.

Fig. 2. Sketch from an optical cross-section of the exoskeletal covering and cuticula. X 384.

Fig. 3. Side view of a female specimen, showing the general character of the proboscis. X 60.

Fig. 4. Outer side of mandible of female. X 294.

Fig. 5. Inner side of same mandible as in the case of Fig. 4. X 294.

Fig. 6. Inner side of left mandible of female. X 250.

Fig. 7. Epimeral field and genital area of female. X 75.

PLATE X.

All Figures of *Xystonotus asper* nov. sp., female.

Fig. 8. Dorsal view of body. X 96.

Fig. 9. Sketch from optical cross-section of the exoskeleton and cuticula. X 384.

Fig. 10. Inner side of left mandible. X 440.

Fig. 11. Outer side of right palpus. X 440.

Fig. 12. General view of body from beneath, the mouth parts removed. X 96.

Fig. 13. Ventral view, at a focus which brings out the form of a section of the body at the level of the constriction dorsad of the origin of the legs, the latter arising from the dorsal side of the epimeral plate. X 96.

Fig. 14. Outline of the claw of the right fore leg. X 650.

Digitized by Google

PLATE XI.

All but Fig. 23, of *Koenikea concava* nov. sp.

Fig. 15. Dorsal view of body of male. X 86.

Fig. 16. Sketch from optical cross-section of the exoskeleton and cuticula. X 650.

Fig. 17. Snout of male from the side. X 294.

Fig. 18. Side view of snout of female. X 416.

Fig. 19. Inner side of left palpus of male. X 625.

Fig. 20. Anterior surface of left leg IV of female. X 156.

Fig. 21. Outer side of left mandible of female. X 305.

Fig. 22. Inner side of left palpus of *Tanaognathus spinipes* nov. sp. X 440.

PLATE XII.

Fig. 23. Outline of epimera of female of *Koenikea concava* nov. sp. X 167.

Fig. 24. Epimeral field and genital area of male of *Koenikea concava* nov. sp. X 130.

Fig. 25. Snout of *Tanaognathus spinipes* nov. sp., side view. X 220.

Fig. 26. Epimeral field and genital area of *Tanaognathus spinipes* nov. sp. X 95.

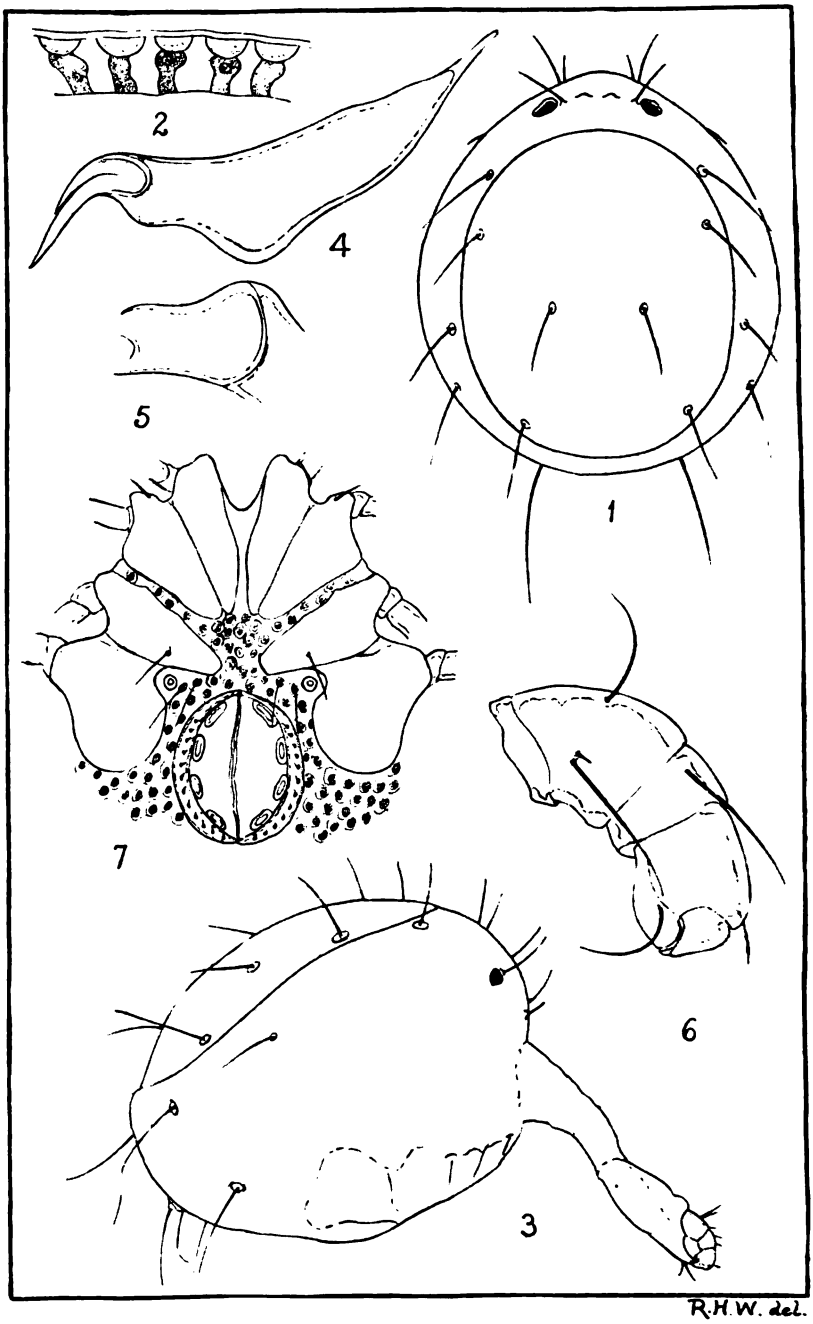
Fig. 27. Anterior surface of left hind leg of *Tanaognathus spinipes* nov. sp. X 187.

Fig. 28. Posterior surface of distal segment and claw of right leg I of *Tanaognathus spinipes* nov. sp. X 130.

Digitized by Google

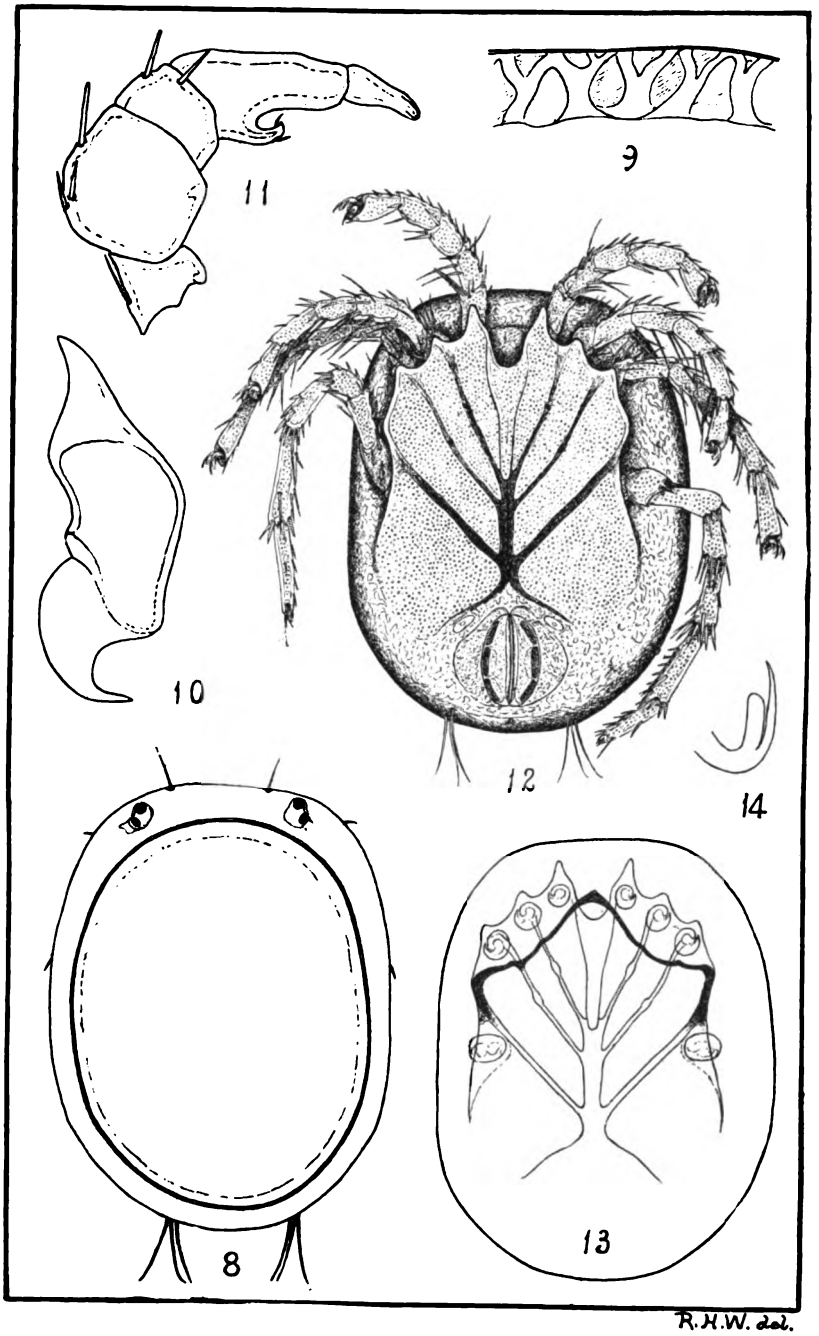
Digitized by Google

PLATE IX



Digitized by Google

PLATE X

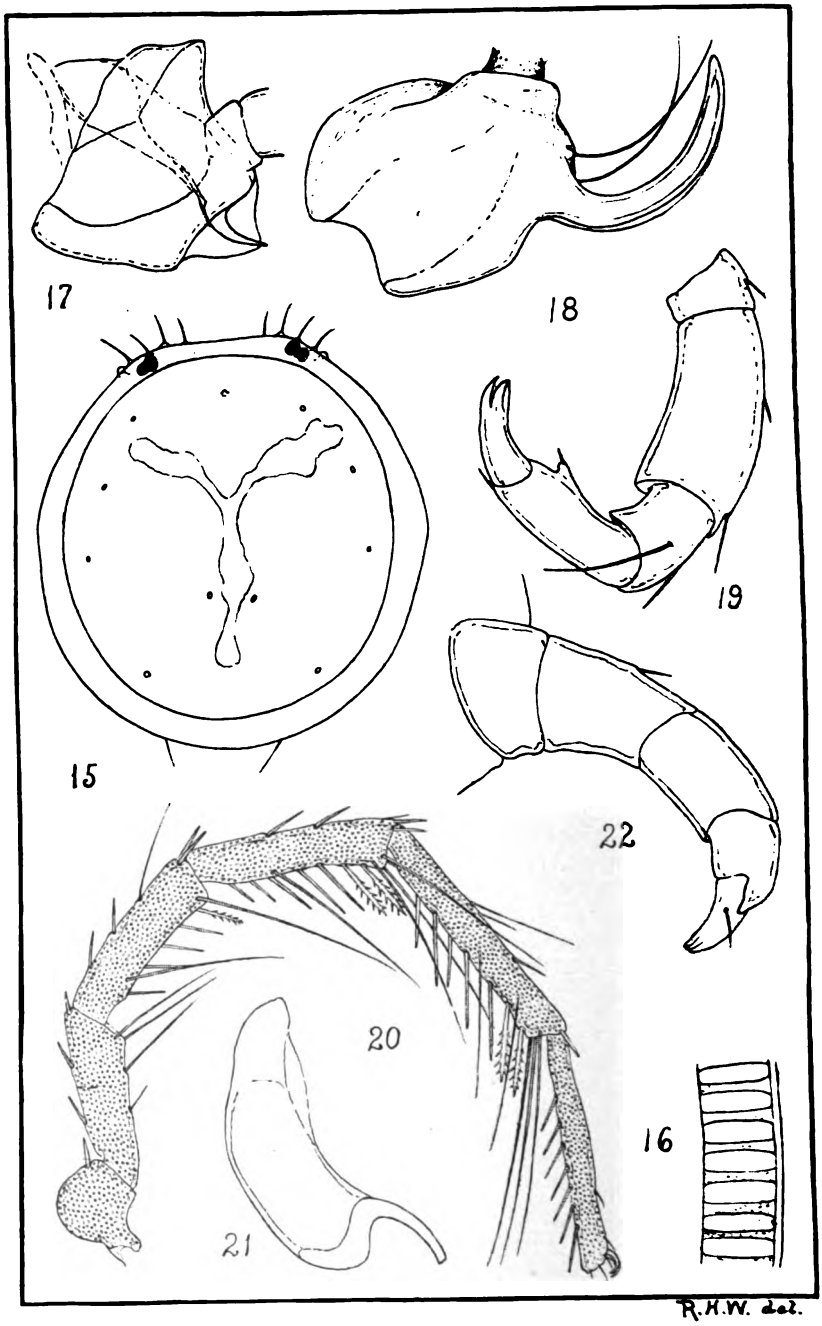


Digitized by Google

Digitized by Google

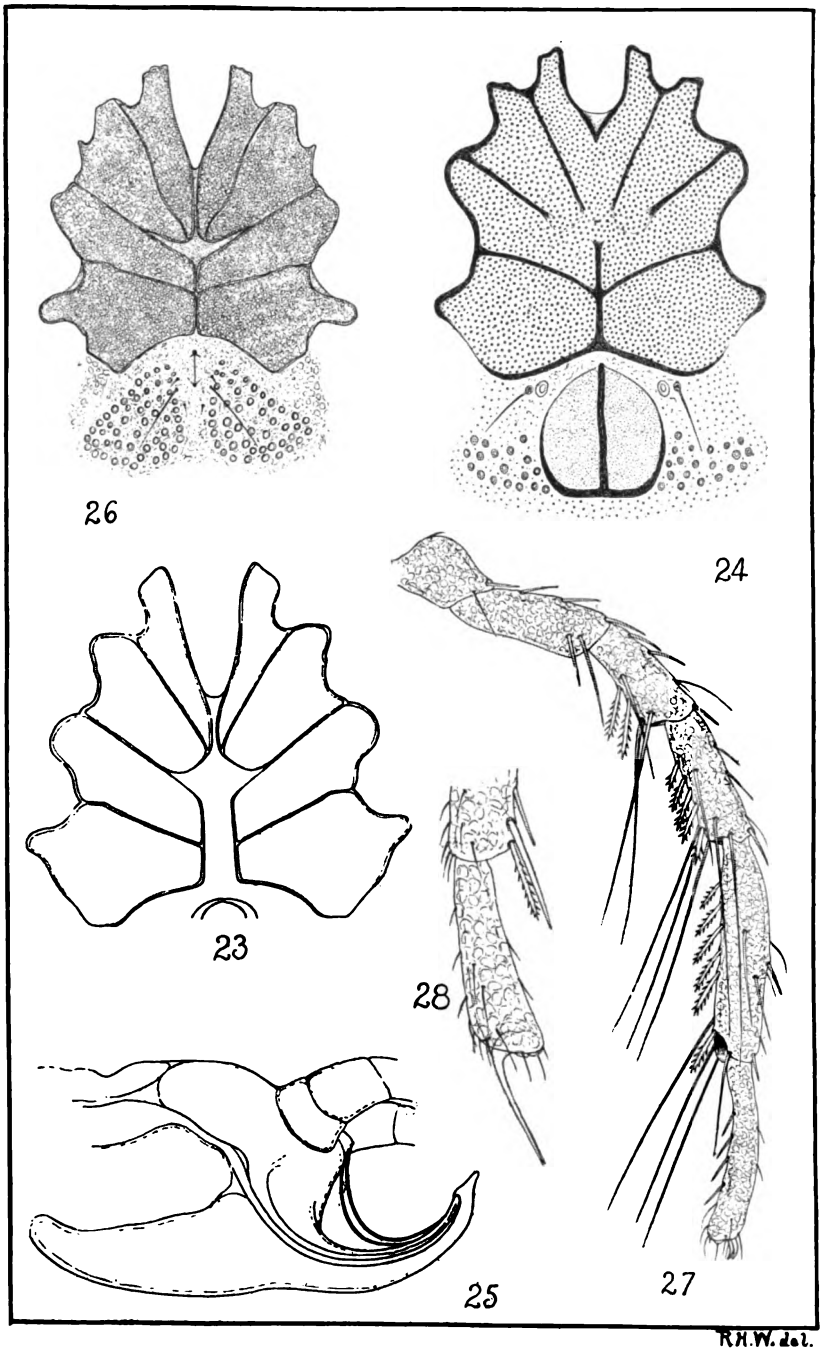
Digitized by Google

PLATE XI



Digitized by Google

PLATE XII



Digitized by Google

Digitized by Google

A PLEA FOR THE STUDY OF LIMNOBIOLOGY.

By HENRY B. WARD.

Historically at least the development of microscopical work is inseparably connected with the study of fresh-water life. The early students with the microscope ransacked ponds and ditches for their material and the works of these pioneers are filled with observations on the organisms of this character. Such names as Leuwenhoek, Swammerdam, Trembly, O. F. Müller, and a whole host of others almost equally well known, recall sources of information on the fresh-water fauna which are of permanent value today. The appearance in 1838 of Ehrenberg's famous volume "The Infusion Animalcules as Complete Organisms" marks in our own times a period of advance coincident with noteworthy improvements in the instrument of research. Since then many investigators of repute and I think it may be confidently asserted the majority of private workers also have found in the fresh-water life of their region the most accessible and most fruitful field of study.

During the earlier years of its history this Society devoted its attention largely to biologic problems, and the majority of these touched in some way upon the life of our inland waters. Thus the work of Vorce on the organisms of Lake Erie, of H. L. Smith and Cox on diatoms and the long series of contributions by Kellicott on the fresh-water fauna marked a tendency which was generally manifested in the public and private work of the Society. Somewhat later this movement declined and the published Proceedings show that the majority of the papers were devoted to technic and to the construction of apparatus, much of it manifesting a thoroughly transient character. There were to be sure occasional papers of the earlier type but even Kellicott, whose contributions are wanting in but one of the first thirteen volumes of the Society Proceedings, failed for five

Digitized by Google

years to add anything in this line of work. There has come, however, of late a decided increase in contributions which may be classed in large part at least in this field since they were worked out on fresh-water vertebrates. The microscopical structure of these forms has been studied with great vigor by an active branch of our membership, and this new movement of Gage and his pupils towards the development of a comparative histology added to the work of the Society an element of great interest and permanent value.

It cannot be doubted, I believe, that mere technic and details of apparatus and its construction do not furnish a sufficient raison d'etre for an organization having a widely distributed membership and seeking to interest a varied class of workers. The topic is secondary, not primary; methods vary greatly in different fields; they often need modification even for different objects of the same character, and must be worked out in large measure by each student to suit his particular problem. The results are thus devoid of general interest or suited rather to the pages of a journal devoted specifically to technic, in which moreover they may be expected to appear with less delay than is incident upon the publication of a large annual volume. Such journals, a few, exist in our own country, and to them I believe this Society should accord its hearty support and at the same time relegate to them for publication papers of this character. It certainly is not wise for us to compete with them in a field already well occupied, especially when our members are getting more of this work and more promptly than we can hope to give it to them.

Some definite lines of work are, however, evidently necessary to hold our membership together, to keep up interest and arouse activity and more than all to attract new members sufficient to meet the annual decline of membership from natural causes and to keep the Society in a healthy condition by the infusion of new blood. Such lines of work must necessarily have certain characteristics if they are to meet the conditions just mentioned. They must be definite, they must attract a considerable number of workers and yet be sufficiently circumscribed to unify the entire

Digitized by Google

membership of the organization. They must moreover possess a permanent value if the work of the organization is to command the attention and respect of the scientific world. It would seem further to be highly advantageous were such aims to be in fields not already occupied by other organizations and other influences. From the past character of this Society it is also apparent that these ends should appeal both to teachers and to private workers, to specialists and to dilettanti, and finally they should have in the microscope the main tool by which their results are to be gained. In them, then, the emphasis is laid not upon means except as they conduce to ends, not upon methods except as they bring results.

It is not difficult from the recent history of the Society to cite a striking concrete illustration of these general principles just elucidated. The work of Gage and his pupils on comparative histology has furnished a decidedly original and permanently valuable portion of the contributions from members during recent years. Other less clearly marked or more strongly individualistic tendencies might be mentioned but the one will suffice.

It is my purpose to call attention here to a field of work in which as already noted this Society was active in its earlier history, and which to a peculiar extent meets the conditions for successful prosecution which have just been discussed. The study of fresh-water life formed the original field of microscopical investigation; in it were prepared as already noted those masterpieces of Leuwenhoek, Swammerdam, Rösel von Rosenhof and a host of other early students with the microscope who contributed so much to the advancement of biological science. In it has been done the major part of the study attempted by private workers with the microscope in all lands. It appeals to the college teacher as well, and aside from the few who are favorably located so that they may have recourse to the shore regularly or in the interval of a vacation, it is the great and only field of work for the inland naturalist. As yet comparatively unoccupied and thus in strong contrast with conditions

Digitized by Google

which prevail in the field of marine biology, it is broad enough in its extent to draw together the most varied workers. The part of the botanist, the zoologist, and even the bacteriologist, in its development is sufficiently clear to need no demonstration, and the solution of its problems will certainly demand the cooperation of the physicist and the chemist in working out the conditions of existence and the processes of change, while its importance from another point of view to the sanitary engineer and to those engaged in solving the practical problems involved in the water supply of the more closely settled portions of our country cannot be over estimated. Although thus extensive in its complete aspect, this topic is yet unusually flexible in the ease with which it may be subdivided. A student of nature may attack any point in this broad field with assurance that careful work, however limited, will meet with adequate returns and if not misdirected contribute proportionally towards the solution of the greater problems in the field. The field is furthermore one which with the development of scientific work, both private and public, throughout the great continental area of our country, will demand the attention and interest of a constantly increasing number of workers. It may profitably even today be forced upon the attention of many who bemoan the fact that their distance from the sea precludes scientific work, for it offers its problems everywhere that a pond may be found or a temporary pool is formed by the spring rains. While it gives an opportunity for all kinds of work, taxonomic, anatomic, embryologic or physiologic, once embarked in the study the investigator will be led sooner or later into the study of conditions of existence and will find in ecology problems presented with a clearness and singleness that cannot be matched elsewhere. In some such a "unit of environment" as one of our members has called the lake, is offered greater simplicity and a more definitely limited problem than is presented in most lines of biologic study. Such a circumscribed region may be held under daily observation and the records of this study will demonstrate the rise and fall of species, the struggle for existence and kindred topics of biological import as they can hardly

Digitized by Google

be seen elsewhere. And all these possibilities lie near the student; instead of asking him to reach after that which for some is unattainable, this field offers an abundance of material close at hand. This again comes before the eye in its living form and impresses the investigator in its character of living working organisms so that in such work it is not difficult to see an antidote for the excessive laboratory tendency which marks the present time, at least in college biologic work.

In thus urgently calling to your attention, a prolific and attractive field of work, let me not neglect to clear myself of one probable imputation. It is not my hope or desire to impress all members in this field of study. The Society has carried on valuable and successful work in many lines and will continue to do so. Here however is room for the unoccupied, and it may be uninterested, student; it will afford him occupation and kindle his zeal. It is preeminently the field for the amateur microscopist and for the professional man who seeks in microscopical studies his pastime. One has only to scan the attractive pages of "Science Gossip" with its wealth of biological observations to see what a hold such studies have on our cousins across the sea. Who can doubt that such work constantly attracts new students to this field of study? Through our continental area there are far more varied conditions and greater opportunities than are offered the English student of fresh-water life and these questions are almost untouched as yet. In considering then the importance, the general interest and variety of such studies and their fruitfulness, no less than their intimate connection with the development of microscopical science and of this organization, is it not just to ask that the Society appoint a special committee or group of workers who shall consider the question of furthering such work and shall report to the Society the best methods for encouraging and directing it in our own country?*

* The recommendations of the Executive Committee and the action of the Society on this matter may be found in the Minutes at the close of this volume.

Digitized by Google

As an index of what this Society has done in the past twenty-one years of its existence the following synopsis and bibliography is presented. Papers have been entered under their main subjects only and none included which do not in first instance treat of some topic in fresh-water biology. Those papers which deal merely with technic are not included though many of them are useful and a few of immediate importance in their bearing on fresh-water biology. Bacteriological contributions are also omitted. Out of a total of 419 separate papers in the twenty volumes of Proceedings and Transactions of the American Microscopical Society, 77 or about twenty per cent. are included in this list.

GENERAL—

Faunistic: Mills, 83; Vorce, 82, 83.
Methods of Work: Conser, 96; Ward, 96a.
Ecologic: Ward, 96.
Summary Review: Ward, 99.

ECONOMIC—

Water Supply: Hyatt, 83; Krauss, 97; Thornbury, 97; Veeder, 97.
Sewage: Bennett, 85.

BOTANIC—

General: Mills, 83; Vorce, 82, 83.
Desmids: Wolle, 84.
Diatoms: Cox, 86, 91, 91a; Durkee, 85; Hyatt, 83; H. L. Smith, 83, 87, 88; Vorce, 86.
Fungi: Bennett, 85.
Chara: Rowlee, 96.
Victoria Regia: Seaman, 92.

ZOOLOGIC—

General: Mills, 83; Vorce, 82, 83.
Protozoa: Fisher, 81; Kellicott, 84, 84a, 85, 85a, 86, 88a, 89, 89b; Perry, 91; Smith, J. C., 98, 98a, 99; Stedman, 89.
Porifera: Mills, 83a, 85, 87; Stedman, 92.
Plathelminthes: Kellicott, 84b; Ward, 94.

Digitized by Google

Annelida: Up de Graff, 84.
Rotatoria: Kellicott, 85a, 86a, 88, 89a, 90, 97, 98; Up de Graff, 84; Vorce, 88, 91a.
Bryozoa: Kellicott, 83a.
Crustacea: Fellows, 88; Kellicott, 80, 80a, 81, 83, 87, 93; Vorce, 91.
Arachnida: Wolcott, 99.

VERTEBRATA—
Blood: Berry, 98; Claypole, E. J., 94; Gage, S. H., 89.
Development: Britcher, 99; Kingsbury, 96a, 99.
Histology: Claypole, A. M., 95; Gage, S. H., 86; Gage, S. P., 96, 97; Green, 97; Hopkins, 91; Kingsbury, 95, 96.

PARASITES—
Kellicott, 80, 80a, 81, 83, 84b, 87, 93; Ward, 94; Wolcott, 99.

LITERATURE.

BENNETT, A. W.
85. Fungi Found in Sewage-Effluents.
Proc. Am. Soc. Mic., VI, 90-92.

BERRY, J. M.
98. A comparison of the Phagocytic Action of Leukocytes in Amphibia and Mammalia.
Trans. Am. Mic. Soc., XIX, 93-116, 5 Pl.

BRITCHER, H. W.
99. An Occurrence of Albino Eggs of the Spotted Salamander, *Amblystoma punctatum* L.
Trans. Am. Mic. Soc., XX, 69-74, 1 Pl.

CLAYPOLE, A. M.
95. The Enteron of the Cayuga Lake Lamprey.
Proc. Am. Soc. Mic., XVI, 125-163, Pls. III-X.

CLAYPOLE, E. J.
94. The Blood of Necturus and Cryptobranchus
Proc. Am. Soc. Mic., XV, 39-76, 6 Pls.

Digitized by Google

CONSER, H. N.
96. Cocaine in the Study of Pond-Life.
Trans. Am. Mic. Soc., XVII, 310-311.

COX, J. D.
86. Some Diatom Hoops. The Question of their Mode of Growth (*Aulacodiscus kittoni*).
Proc. Am. Soc. Mic., VII, 83-87.

91. Deformed Diatoms.
Proc. Am. Soc. Mic., XII, 178-183, 1 Pl.

91a. The Coscinodisceae. Notes on Some Unreliable Criteria of Genera and Species.
Proc. Am. Soc. Mic., XII, 184-204, 2 Pl.

DURKEE, R. P. H.
85. The Structure of the Diatom Valve.
Proc. Am. Soc. Mic., VI, 105-9.

FELLOWS, C. S.
88. A Description of *Ergasilus chautauquaensis*. A new species of Copepoda, and a list of other Entomostraca found at Lake Chautauqua, in August, 1886.
Proc. Am. Soc. Mic., IX, 246-249, 1 Pl.

FISHER, J. H.
81. Notes on the Structure, Development, and Position of an undescribed Flagellate Infusorian.
Proc. Am. Soc. Mic., II, 44-49, 2 colored Pls.

GAGE, S. H.
86. Notes on the Epithelium Lining the Mouth of Necturus and Menopoma.
Proc. Am. Soc. Mic., VII, 126-127.

89. The Form and Size of the Red Blood Corpuscles of the Adult and Larval Lamprey Eels of Cayuga Lake.
Proc. Am. Soc. Mic., X, 77-88.

GAGE, S. P.
96. Comparative Morphology of the Brain of the Soft-Shelled Turtle (*Amyda mutica*) and the English Sparrow (*Passer domestica.*)
Trans. Am. Mic. Soc., XVII, 185-238.

97. The Brain of the Embryo Soft-Shelled Turtle.
Trans. Am. Mic. Soc., XVIII, 282-286.

GREEN, I. M.
97. The Peritoneal Epithelium of some Ithaca Amphibia.
Trans. Am. Mic. Soc., XVIII, 76-106, 5 Pls.

HOPKINS, G. S.
91. Structure of the Stomach of *Amia calva*.
Proc. Am. Soc. Mic. XII, 165-169, 1 Pl.

Digitized by Google

HYATT, J. D.

88. Sporadic Growth of Certain Diatoms and the Relation Thereof to Impurities in the Water Supply of Cities.
Proc. Am. Soc. Mic., IV, 197-199.

KELLICOTT, D. S.

80. On Certain Crustacea Parasitic on Fishes from the Great Lakes.
Proc. Am. Soc. Mic., I, 3-57, 8 Pls.

80a. Observations on *Lerneocera cruciata*.
Proc. Am. Soc. Mic., I, 64-68.

81. *Lerneocera tortua*, n. s.
Proc. Am. Soc. Mic., II, 41-43, 1 Pl.

83. On Certain Crustaceous Parasites of Fresh-Water Fishes.
Proc. Am. Soc. Mic., IV, 75-78.

83a. Polyzoa. Observations on Species Detected near Buffalo, N. Y.
Proc. Am. Soc. Mic., IV, 217-229, 1 Pl.

84. On Some Infusoria Found on the Cray-Fish.
Proc. Am. Soc. Mic., V, 105-111.

84a. *Cothurnia lata*. n. s.
Proc. Am. Soc. Mic., V, 113-114.

84b. Notes on Two Parasites of the Cray-Fish.
Proc. Am. Soc. Mic., V, 115-116.

85. Observations on Infusoria, with Descriptions of New Species.
Proc. Am. Soc. Mic., VI, 110-125, 1 Pl.

85a. Notes: Infusoria, Rotatoria, etc.
Proc. Am. Soc. Mic., VI, 126-130.

86. Observations on Some Fresh-Water Infusoria. With Descriptions of a Few Species Regarded as New.
Proc. Am. Soc. Mic., VII, 38-47, 1 Pl.

86a. A New Floscule.
Proc. Am. Soc. Mic., VII, 48-50, 1 Pl.

87. A Note on *Argulus catostomi*.
Proc. Am. Soc. Mic., VIII, 144.

88. Additional Notes on Certain Species of Rotifera.
Proc. Am. Soc. Mic., IX, 181-186.

88a. Some New and Rare Infusoria.
Proc. Am. Soc. Mic., IX, 187-190.

89. The Nature of Protozoa and Lessons of these Simplest Animals.
Proc. Am. Soc. Mic., X, 5-32.

89a. Partial List of Rotifera of Shiawassee River at Corunna, Michigan.
Proc. Am. Soc. Mic., X, 84-96.

89b. Observations on Fresh-Water Infusoria.
Proc. Am. Soc. Mic., X, 97-106.

Digitized by Google

90. A New Rotiferon.
Proc. Am. Soc. Mic., XI, 32-33.

93. A Crustaceous Parasite of the "Miller's Thumb" (Cottus).
Proc. Am. Mic. Soc., XIV, 76-79.

97. The Rotifera of Sandusky Bay.
Trans. Am. Mic. Soc., XVIII, 155-164.

98. The Rotifera of Sandusky Bay (Second Paper).
Trans. Am. Mic. Soc., XIX, 43-54.

KINGSBURY, B. F.

95. The Histological Structure of the Enteron of *Necturus maculatus*.
Proc. Am. Mic. Soc., XVI, 19-64, 8 Pls.

96. The Lateral Line System of Sense Organs in some American Amphibia, and Comparison with the Dipnoans.
Trans. Am. Mic. Soc., XVII, 115-154, 5 Pls.

96a. The Spermatheca and Methods of Fertilization in some American Newts and Salamanders.
Trans. Am. Mic. Soc., XVII, 261-304, 4 Pls.

99. The Regeneration of the Intestinal Epithelium in the Toad (*Bufo lentiginosus americanus*) during Transformation.
Trans. Am. Mic. Soc., XX, 45-48.

KRAUSS, W. C.

97. The Requisites of a Pure Water-Supply.
Trans. Am. Mic. Soc., XVIII, 165-175.

MILLS, H.

83. Microscopic Organisms in the Buffalo Water-Supply and in Niagara River.
Proc. Am. Soc. Mic., IV, 165-175.

83a. Fresh-Water Sponge.
Proc. Am. Soc. Mic., IV, 209-216, 1 Pl.

85. Thoughts on the Spongidae with Reference to the American Sponges of the Fresh-Water Group, with some Account of them in Detail.
Proc. Am. Soc. Mic., VI, 131-147.

87. Notes on the Fresh-Water Sponges.
Proc. Am. Soc. Mic., VIII, 132-139.

PERRY, S. H.

91. Rhizopods of Oakland County, Michigan.
Proc. Am. Soc. Mic., XII, 94-96.

ROWLEE, W. W.

96. The Chlorophyll Bodies of *Chara coronata*.
Trans. Am. Mic. Soc., XVII, 155-156.

SEAMAN, W. H.

92. The Victoria Regia.
Proc. Am. Soc. Mic., XIII, 163-170.

Digitized by Google

SMITH, H. L.
83. *Rhizosolenia gracilis*, n. sp.
Proc. Am. Soc. Mic., IV, 177-178.
87. A Contribution to the Life History of the Diatomaceae.
Proc. Am. Soc. Mic., VIII, 30-66, 5 Pl.
88. A Contribution to the Life History of the Diatomaceae, II.
Proc. Am. Soc. Mic., IX, 126-167, 6 Pls.

SMITH, J. C.
98. Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana.
Trans. Am. Mic. Soc., XIX, 55-68, 1 Pl.
98a. The Sporular Development of the *Ameba villosa* Leidy.
Trans. Am. Mic. Soc., XIX, 69-73.
99. Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana.
Trans. Am. Mic. Soc., XX, 51-56, 1 Pl.

STEDMAN, J. M.
89. On the Development and a Supposed New Method of Reproduction in the Sun Animalcule—*Actinosphaerium eichhornii*.
Proc. Am. Soc. Mic., X, 107-118, 1 Pl.
92. The Nervous System of the Fresh-Water Sponge.
Proc. Am. Soc. Mic., XIII, 77-78.

THORNBURY, F. J.
97. The Increasing Pollution of Our Municipal Water-Supplies.
Trans. Am. Mic. Soc., XVIII, 182-198.

UP DE GRAFF, T. S.
84. Descriptions of Certain Worms.
Proc. Am. Soc. Mic., V, 117-119.

VEEDER, M. A.
97. Public Water-Supply for Small Towns.
Trans. Am. Mic. Soc., XVIII, 176-181.

VORCE, C. M.
82. Forms Observed in Water of Lake Erie.
Proc. Am. Soc. Mic., III, 51-60, 1 Pl.
88. Microscopic Forms Observed in Water of Lake Erie.
Proc. Am. Soc. Mic., IV, 187-196, 1 Pl.
86. Remarks on *Stephanodiscus niagarae*.
Proc. Am. Soc. Mic., VII, 139-141.
88. Note on a New Rotifer, *Gomphogaster areolatus*.
Proc. Am. Soc. Mic., IX, 250-252, 1 Pl.
91. A New Daphnella.
Proc. Am. Soc. Mic., XII, 172-173.
91a. Additional Notes on *Gomphogas'er*.
Proc. Am. Soc. Mic., XII, 174-177.

Digitized by Google

WARD, H. B.

94. On the Parasites of the Lake Fish.
Proc. Am. Mic. Soc., XV, 178-182, 1 Pl.

96. The Food Supply of the Great Lakes; and Some Experiments on its Amount and Distribution.
Trans. Am. Mic. Soc., XVII, 242-254, 2 Pls.

96a. A New Method for the Quantitive Determination of Plankton Hauls.
Trans. Am. Mic. Soc., XVII, 255-260.

99. Fresh-Water Investigations During the Last Five Years.
Trans. Am. Mic. Soc., XX, 261-336.

WOLCOTT, R. H.

99. On the North American Species of the Genus Atax (Fabr.) Brux.
Trans. Am. Mic. Soc., XX, 193-259, 5 Pls.

WOLLE, F.

84. Note on the Desmidiae of the United States.
Proc. Am. Soc. Mic., V, 137-189.

Digitized by Google

A NEW AVIAN CESTODE—*METROLIASTHES LUCIDA.*

By B. H. RANSOM.

WITH PLATES XIII AND XIV.

The material worked up into the subject matter for this paper was obtained preserved in formol in two vials from a collection belonging to Dr. H. B. Ward. One vial contained what was apparently a single worm broken into three pieces, one of which included the head; the other vial contained pieces of two or more worms of the same kind as that of the first vial, but no head. The labels in the vials gave as the host, the domestic turkey; and the organ infested, the intestine. The specimens were collected in the vicinity of Lincoln, Nebraska.

The characteristics of the worm to be gathered from a superficial examination are as follows:

Length about 20 cm. Greatest width 1.5-1.8 mm. Width just behind the head 0.6 mm. The most anterior proglottides are five or six times wider than long; but in the older segments with the general increase in size, there is an added increase in length, so that the last proglottides are nearly twice as long as broad, being 2.5-3 mm. long by 1.5-1.8 mm. wide (Figs. 2, 7 and 8).

The head is somewhat spherical with its anterior surface exhibiting a slightly conical convexity (Fig. 1). In the compressed specimen the head is broader than long, measuring 0.58 mm. in length by 0.75 mm. in width. It has neither hooks nor rostellum. The four round suckers are prominent and well developed, and are situated somewhat anteriorly. They measure 0.2-0.25 mm. in diameter.

Digitized by Google

The strobilation of the worm becomes apparent immediately behind the head, and very distinct within a distance of two millimeters. In a contracted state of the worm the posterior portion of the proglottis forms a prominent projecting rim which overlaps more or less the anterior part of the succeeding proglottis. In some of the younger proglottides this overlapping covers the next segment for half its length. In all cases this border is a well developed part of the proglottis.

The worm is rather transparent throughout, in its posterior portion remarkably so. Some seven to ten centimeters from the anterior end of the worm one may notice a white spot in each proglottis, situated in the median line near the posterior border and occupying about one-third its width. This structure has the form of a double spherical sac, as becomes very evident with the increasing size and transparency of the proglottides. A little conical projection develops running forward from this sac in the median line of the segment (Fig. 2, FC). Later a bulb-like swelling appears at the anterior end of this projection. In the oldest proglottides only a trace of the double posterior sac (Fig. 7, U) remains, while the anterior bulb has become a well marked little spherical body (EC), situated in the posterior half of the proglottis with a diameter of from one-third to one-half the width of the latter.

The cirrus sac can be seen under slight magnification without difficulty. From the margin somewhat posterior to the middle of the proglottis it runs diagonally forward and inward, ending shortly after crossing the excretory canal. The angle it makes with a line drawn transversely across the proglottis increases with age. One cause at least of this change in the angle of the cirrus sac is the growth of organs behind it, the pressure of which shoves its inner end forward. It is found well preserved in the oldest proglottides. Its shape is that of a slender cylindrical flask, and its most usual adult size approximates 100μ by 400μ (Figs. 2, 5, 7 and 10).

Posterior to the cirrus sac the vagina (V) and seminal receptacle (RS) are often visible running towards the middle of the proglottis.

Digitized by Google

The genital pores are marginal and are located a little posterior to the middle of the segment. The margin around the opening is often bulged out into a papilla of more or less prominence and the pores alternate very irregularly.

INTERNAL ANATOMY.

Body Wall.—The cuticula varies in thickness from 3 to 6μ, and beneath are found the usual layers of circular and longitudinal muscles and of subcuticular cells.

Musculature.—The longitudinal muscle fibres are disposed in a layer of which two parts can be distinguished, an inner part consisting of about one hundred bundles of twelve to twenty fibers each, and an outer part consisting of fibers, arranged in bundles of three to five or isolated, scattered through the parenchyma and lying externally to the inner portion. The diameter of these fibers ranges from 1.5 to 4μ. The inner portion is continuous from segment to segment, while a great deal of the outer part is interrupted by the strobilation.

The transverse musculature lies in a thin band of fine fibers just within the ring of the longitudinal bundles. Except for portions of the cirrus sac and vagina all the organs of the proglottis lie within the transverse muscle bands. Laterally the fibers of this layer penetrate the longitudinal muscle layer, spreading out and attaching to the cuticula. The dorso-ventral muscle system is well developed.

Excretory System.—The ventral canals (Figs. 5, 8, 9 and 10, VC) vary in size from 40 to 180μ, and are very much larger than the dorsal. In the old segments where the ventral canal attains its maximum size the dorsal canal, has, on the other hand, become very insignificant, with an inner diameter of sometimes less than 1μ. The wall of the dorsal canal, however, is much thicker than that of the ventral canal, and commonly as thick as the lumen which it encloses. In the posterior part of each segment the two ventral vessels are connected by an anastomosis whose ramifications run behind and among the testes.

Digitized by Google

Sexual Organs.—Numerous testes are found in a mass in the posterior portion of the proglottis, occupying the middle field, and extending transversely from one ventral canal to the other (Figs. 5 and 8, T). They are arranged in two layers which contain two or three rows each in the lateral region, while at the middle they are only one or two deep, so that the mass is somewhat concave anteriorly. Medianly and ventrally in this concavity lies the yolk gland (Vit). Close to the yolk gland and in the direction towards the genital pore is the shell gland (SG). The ovary (Ov) lies anterior to the yolk and shell glands and dorsal to its posterior edge is the uterus (U). The cirrus sac (CP) lies with its proximal end near the anterior edge of the ovary and somewhat dorsal to it, and with the vagina running nearly parallel to it, passes between the excretory canals and dorsal to the nerve cord towards the margin of the proglottis.

Male.—The testes number about 35 or 40. They are approximately oval except where modified by pressure and range in size from 30 to 100μ. The number given is the maximum, found in youthful proglottides (Fig. 8), and with the growth of the various organs is reduced so that when the uterus begins active growth, only about twenty to thirty testes will be found, most of them approaching the maximum size.

In the median line of the proglottis two or three efferent ducts, in diameter 2 or 3μ, join to form the vas deferens. This structure (Fig. 5, VD), lies just beneath the dorsal transverse muscle layer. It runs forward near the median line in a straight or sinuous course, then bends toward the cirrus sac and twists and curves about the base of the latter in a mass of coils. The bulk of the mass lies anterior and median to the cirrus sac, several coils lie ventral, and there is a twist or two on the dorsal side, but practically none posterior. The vas deferens is surrounded throughout its course by a clear transparent sheath which finally merges into a similar sheath (CS) surrounding the cirrus sac and vagina.

The slender flask-shaped cirrus sac consists of a thick outer muscular layer, surrounding a tissue of a reticular nature in

Digitized by Google

whose midst is the cirrus (Fig. 5, C). The muscle layer has a thickness of 1 to 4μ, and consists of circular, diagonal, and a few longitudinal fibers. There is apparently also a system of fibers running radially from the cirrus to the muscular wall of the sac; but the base of the sac is free from such fibers. The sheath surrounding the sac (CS) is clear and transparent, of a fibrous or reticular nature, and towards its distal end merges imperceptibly into the general parenchymatous tissue of the proglottis.

The vas deferens penetrates the base of the sac and after one or two twists expands into the cirrus (C), which is spindle or cigar-shaped with a short curve at its inner end. Its wall is thin and is surrounded by a system of circular fibers. Within the wall of the cirrus reaching from one end to the other is a compact bundle of highly refractive, fine, smooth fibers. There seems to be no other conclusion as to the nature of these fibers than that they are enormously developed spines. Their size is truly extraordinary, some of them apparently reaching the whole length of the cirrus. The partial extension of the cirrus and its position in the vagina in one case observed among the numerous proglottides sectioned (Fig. 4), seems to indicate the occurrence of self impregnation, a phenomenon already noticed by various authors in many different species. In this connection I might say in passing that it is very common in sections I have of *Taenia cesticillus*, to find the cirrus well entered into the vagina of the same proglottis. In none of my preparations of the worm which forms the subject of this article does a cirrus protrude beyond the genital opening. The genital sinus is deep and narrow.

Running diagonally forward and inward across the ventral canal where the cirrus crosses it is a thin strip of tissue. This strip reaches across the canal and joins the wall both dorsally and ventrally, closing it except for a small opening at its outer edge (Fig. 10, x). Its function is problematical but it is evidently not a valve of the ordinary type at least.

Female Sexual Organs.—The vagina (Figs. 4 and 5, V) is a comparatively straight tube of 6 to 9μ in diameter. It opens

Digitized by Google

into the genital sinus just posterior to the cirrus opening and almost at right angles to it. Following the curve of the tip of the cirrus sac it runs toward the center of the proglottis keeping a position posterior to the sac and becoming also somewhat ventrally situated. The first bit of the vagina has a tolerably wide lumen and walls whose thickness varies in different specimens. The diameter of the passage soon narrows to about 2μ, the walls thicken, and are lined on their inside with bristle-like projections directed outward (Fig. 4, Cl). On the outside this thick walled region is surrounded by a heavy coat of glandular or myoblastic cells (Fig. 5, a) which deteriorate with the age of the proglottis. Before the excretory canal has been crossed the lumen widens again and the walls become thin. After copulation this thin walled region is seen to be filled with spermatozoa. It has swollen to several times its former size and functions as the seminal receptacle (Fig. 2, RS).

At its inner end the seminal receptacle branches into two tubes; one of these leads to the ovary, the other to the shell gland. The former I have designated as the ascending portion of the oviduct (Fig. 5, Ovd. a), the latter as the descending portion (Ovd. d). With age these tubes grow both in diameter and length, become more or less coiled or twisted and their walls become thinner. They are enveloped by the same transparent sheath (CS), as are also the remaining male and female canals. The ascending oviduct opens into the ovary ventrally on its posterior surface by a funnel-like opening of 30μ in diameter. No structure is present which could be regarded as an oocapt.

The ovary (Ov) is situated in the middle of the proglottis lying close against the ventral transverse muscle band and when well developed it reaches almost to the dorsal layer. It is a single sac-like organ divided into compartments. When filled with ova it has a plump rounded appearance, convex anteriorly and somewhat concave and sunken in behind where the oviduct opens into it. In cross-sections through its posterior part the ovary often presents the appearance of being bilobed,

Digitized by Google

but sections through every other region show that it is clearly single and unpaired. The ova measure from 4 to 6μ in diameter. After the ova have left the ovary it flattens out, shrinks and dwindles away.

From its point of union with the seminal receptacle and ascending portion of the oviduct the descending portion (Ovd. d) pursues its course, slightly sinuous and twisted in the mature state, to the shell gland.

This structure (SG) is oval in section with its long axis directed dorso-ventrally. In the stage when the eggs have begun to fill the uterus, the shell gland has acquired a vacuolated or honey-combed appearance and after the filling of the uterus it degenerates rapidly and disappears.

As the oviduct enters the ventral side of the shell gland it is met by the vitelline duct (YD) which is about 15μ in diameter; it opens with a funnel-like enlargement of 30μ into the vitelline gland (Vit). The vitelline gland has a sacculated structure like that of the ovary but is smaller, being about half the size of the latter and more compact. When the uterus begins to take on its function as an egg receptacle the vitelline bodies break up into tiny eosinophilous granules, which are very persistent and in the oldest proglottides the remnants of the vitelline gland can be identified by their presence.

On entering the shell gland the oviduct becomes the ootype (Ot). This turns anteriad from the shell gland and after a short curved course empties into the uterus. The ootype has a diameter of 10μ and preserves its embryonic structure longer than any other of the female tubes. With progressing development of the uterus, the ootype grows longer and describes two or three loops in its course; its walls also become thin.

The uterus at an early stage (Fig. 5, U) is a transverse band of embryonic cells lying dorsal to the ovary and close behind its posterior edge. It extends somewhat beyond the limits of the ovary on each side and is joined near its middle by the ootype. The cavity of the uterus is formed by a hollowing out of the mass of cells and develops into a double spherical sac

Digitized by Google

which increases rapidly in size as it fills with eggs (Figs. 2 and 10, U). At the height of its development the uterus occupies almost the whole of the inner parenchyma back of the genital pore, and bulges out the proglottis wall dorsally and ventrally.

The eggs as they first appear in the uterus are in early stages of cleavage. They are surrounded with a very delicate envelope and measure about 20μ in diameter. During the sojourn of the egg in the uterus two more coverings become apparent, making the three enveloping membranes so common among cestode eggs (Fig. 3).

Shortly after the eggs have taken up their position in the uterus important modifications occur in the proglottis. Just anterior to the uterus within a cone-shaped space (Figs. 2 and 10, FC), the parenchyma becomes spongy with greatly thickened fibers. Many of these fibers are grouped into strands running transversely in zigzag wavy lines. Next to the uterus, instead of this appearance of striation, there is a more pronounced mesh-work or sponge-like network. The ovary does not enter in any way into the formation of this structure as its remains still persist ventral to the latter. With the progressing development the cone-shaped organ takes on a more definite structure. Some of the fibers group themselves to form a surrounding wall; their course in this wall is mainly in a circular direction. This wall, however, is not so compact that fibers do not exist which, arising in the external parenchyma, penetrate the wall and extend into the interior. The fibers enclosed within the wall become fine and form a hair-like mass. In the posterior part of the cone next the uterus, may be noticed running in a dorso-ventral direction amid these hair-like fibers, and apparently differentiated from them, some five or six bands of tissue which dorsally and ventrally unite with the fibrous enveloping wall of the cone (Figs. 2, 9 and 10, a). These bands unite also with the heavy fibers of a reticular or lace-like frame-work which covers the front of the uterus (Fig. 9, b). Certain modifications also take place in the structure of the latter. All traces of its epithelial cells disappear and it becomes enveloped

Digitized by Google

with a layer of fibrous network. Membranous partitions run inward from its wall branching and ramifying through its cavity among the developing embryos which now exhibit clearly the three-shelled condition.

At a later stage the embryos begin to pass out of the uterus. They leave it in groups carrying with them the intra-uterine partitions. Passages are kept open for the eggs by the dorso-ventral bands (Fig. 9, a). The cone-shaped structure contracts posteriorly so that it becomes cylindrical. Group by group the eggs are forced into the anterior part of the cone until it bulges out into an oval capsule (EC). This capsule increases in size as the eggs enter. During the passage of the egg masses through the fibrous tissue which fills the cavity of the cone-shaped structure, they gather heavy coatings of this tissue. It is this tissue which gives the wall of the capsule its thickness. The primary wall (Fig. 9, EC) is quite thin.

After the last groups of eggs have passed into it the egg capsule finally draws together posteriorly and the resulting spherical capsule is the final stage of development (Fig. 7).

At the tip of the cone-shaped structure or in front of the egg capsule will be found a triangular-shaped thickening or condensation of the parenchyma (Figs. 2, 7, 9 and 10, PC), whose function I do not know. From the appearance of fibers extending radially forward in the parenchyma from its tip, it seems to mark the attachment of supporting or contractile elements. The strain brought about by the development of the egg capsule and the migration of the eggs causes a retraction of the parenchyma from the anterior end of the proglottis leaving an open space bridged across by a number of taut straight fibers.

The adult uterine embryo, i. e., the embryo at that stage of development when it abandons the uterus, is surrounded by three envelopes, a very thin inner membrane closely enveloping the onchosphere, a thick middle envelope, and a thin outer shell of more or less irregular shape (Fig. 3). Between the middle and outer shells is a granular substance commonly in

Digitized by Google

two masses at opposite ends of the egg. The hooks of the onchosphere are of two kinds, one with a short double ventral spur, the other without any spur (Fig. 6). The length of the former is about 20μ, that of the latter some 4 or 5μ greater. The prong of each kind measured about 8μ. The dimension of the embryo (Fig. 3) are as follows: Onchosphere 30μ in diameter, middle shell 35x55μ, outer shell 50x75μ.

SYSTEMATIC POSITION.

In the last sheets of his work on Cestodes Braun (00) has given a revised system of classification. According to this classification the tape worm here in question comes under the order Cyclophyllidea. True, the ovary of our worm is not bilobed but single and unpaired, while Braun gives among the characteristics of the order Cyclophyllidea "Keimstock mehr oder weniger zweilappig." That this expression, however, is meant to be interpreted very freely is shown by the fact that numerous forms possessing only a single ovary, such as *Taenia dispar* Goeze, *Taenia dujardini* Kr., *Taenia planissima* S. and H., *Taenia bifaria* v. Sieb., are arrayed by Braun under this order without any restrictions. And the diagnosis of the genus *Panceria* reads plainly "Keimstocke nicht zweilappig."

Therefore, since the bilobed nature of the ovary cannot be looked upon as an especially distinctive characteristic of the order no discrepancy arises in placing this worm in it, and likewise in the family Taeniidae which has the characteristics of the order.

Among the subfamilies it is the Dipylidiinae, an extensive group of elastic capacity, with whose characteristics our worm corresponds. The genera cited under this subfamily show numerous rather wide differences in structure. For example some have doubled reproductive organs; in some the rostellum is well developed and bears hooks; in others hooks and rostellum are absent; the number of testes varies from three to thirty or forty; and the fate of the uterus and the final position of the eggs in the proglottides are also very varied. With respect to the last point, viz., the fate of the uterus, the

Digitized by Google

genera in this subfamily can be divided into several groups; one containing those forms in which the uterus is persistent; another, those in which the uterus breaks down into egg capsules; and a third those in which the uterus disappears altogether leaving the eggs imbedded singly in the parenchyma. In the first group would fall the genera *Hymenolepis*, *Dilepis*, *Choanotaenia*, *Amoebotaenia*; in the second *Dipylidium*, *Cotugnia*, *Nematotaenia*; and in the third *Oochoristica*, *Panceria*, and *Monopylidium*. A fourth group is represented by a new genus *Anonchotaenia* established by Cohn (00) upon the basis of a new species *A. clava* described by him. In this species the uterus unites with the shell gland to form a large cavity filled with eggs. Yet another condition is met with in our species. The uterus breaks down into a few large egg sacs or masses which are carried forward in the proglottis and become enclosed together in a specially formed capsule.

In certain respects our species resembles Cohn's new species but in others it is radically different. Like *A. clava* the head is unarmed, and the rostellum absent. The neck, however, is short or wanting, while in *A. clava* it is long. The relation in *A. clava* between the breadth and width of the proglottis in different portions of the chain, viz., several times broader than long anteriorly, and posteriorly nearly twice as long as broad, is very similar to the conditions obtaining in ours. The irregularly alternating pores are common to both species; but while those of Cohn's species are situated considerably towards the anterior end of the proglottis those of ours are more posterior. Both forms agree in possessing a non-lobed ovary. In regard to the arrangement of the sexual organs there is a wide disagreement. In *A. clava* beginning in the anterior part of the proglottis, the organs follow each other thus: Shell gland, uterus, ovary, and yolk gland. There is no definite ootype, the shell gland lying against the uterus and opening directly into it instead. All of these points differ widely from our species. While the two species resemble each other in possessing an egg capsule, they are very different, as already noticed, in regard to the origin of this capsule. The number of testes in

Digitized by Google

A. clava is rather small; in our species, on the other hand, considerable.

In Stiles (96) there are some figures (268-270) and a very incomplete description of a cestode, *Taenia nigropunctata* Crety, from the migratory quail, which indicate some resemblances with our form. There is an unarmed scolex without rostellum and a three-shelled egg as in ours while the structure outlined in the proglottis, if it were located more posteriorly, would be strikingly similar to the appearance of certain stages of the uterus with the developing egg capsule in front, of our form. Whether there is anything in this resemblance is a question which of course must remain until more careful investigation of *T. nigropunctata* has been made.

It is quite evident that our species belongs to no genus yet described. Accordingly it is necessary to establish a new genus for its reception. The diagnosis will read:

METROLIASTHES.*

Scolex in adult unarmed, without rostellum. Genital pores irregularly alternating. Uterus breaks up into egg-sacs or masses, which in turn leave this region, and become enclosed by a specially formed secondary capsule.

Type species: *Metroliasthes lucida.*†

Characteristics as given above. From the small intestine of the domestic turkey collected near Lincoln, Nebraska. Type specimens in the collection of the Zoological Department, The University of Nebraska, and in those of B. H. Ransom and H. B. Ward.

Zoological Laboratory,

The University of Nebraska.

* Referring to the disappearance of the uterus.

† By virtue of its unusual transparency.

Digitized by Google

LITERATURE.

BRAUN, M.
94-00. Würmer. In Vol. IV, Bronn's Klassen und Ordnungen des Thierreichs. Leipzig.

COHN, L.
00. Zur Kenntnis einiger Vogeltaenien (Vorläufige Mittheilung). Zool. Anz., XXIII, p. 91.

STILES, CH. W.
96. Tapeworms of Poultry. Bulletin No. 12, Bureau of Animal Industry, Depart. of Agric., U. S. A.

Digitized by Google

EXPLANATION OF PLATES.

ABBREVIATIONS.

C.	Cirrus.
CP.	Cirrus pouch.
CS.	Sheath surrounding genital canals.
EC.	Wall of egg-capsule.
FC.	Fibrous mass in which is developed later the secondary egg-capsule.
N.	Longitudinal nerve.
Ot.	Ootype.
Ov.	Ovary.
Ovd. a.	Oviduct, ascending portion.
Ovd. d.	Oviduct, descending portion.
PC.	Terminal cone of condensed parenchyma.
PS.	Sheath of cirrus pouch.
RS.	Seminal receptacle.
SG.	Shell gland.
T.	Testis.
U.	Uterus.
V.	Vagina.
VC.	Ventral canal.
VD.	Vas deferens.
Vit.	Vitelline gland.
YD.	Vitelline duct.

PLATE XIII.

Fig. 1. Head and portion of strobila from a toto preparation. X 81.

Fig. 2. Proglottis from a region posterior to middle of worm. Toto preparation. X 29.

Fig. 3. Embryo from adult uterus. X 758.

Fig. 4. Longitudinal section through anterior portion of cirrus sac and vagina showing cirrus apparently in the act of entering vagina. X 495.

Fig. 5. Young female sexual organs. X 98.

Fig. 6. Embryonic hooks. X 1712.

PLATE XIV.

Fig. 7. A mature proglottis from end of chain. Toto preparation. X 32.

Fig. 8. Anterior proglottides from toto preparation. X 28.

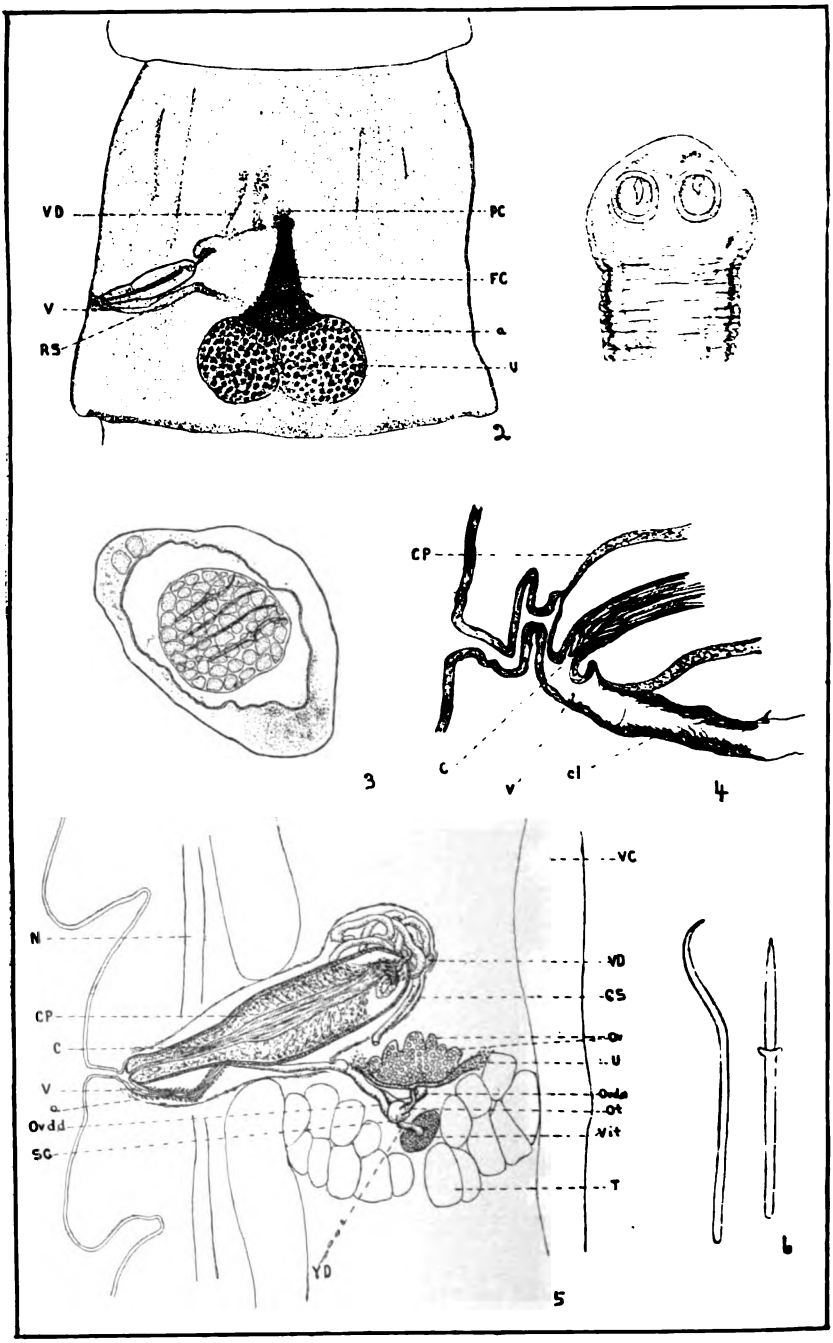
Fig. 9. Longitudinal section of maturing proglottis older than Fig. 10. *a*. Dorso-ventral bands of tissue between which the eggs pass. X 48.

Fig. 10. Longitudinal section of maturing proglottis, eggs just beginning to pass out of uterus at *c*. *x*. Valve-like structure in canal. X 39.

Digitized by Google

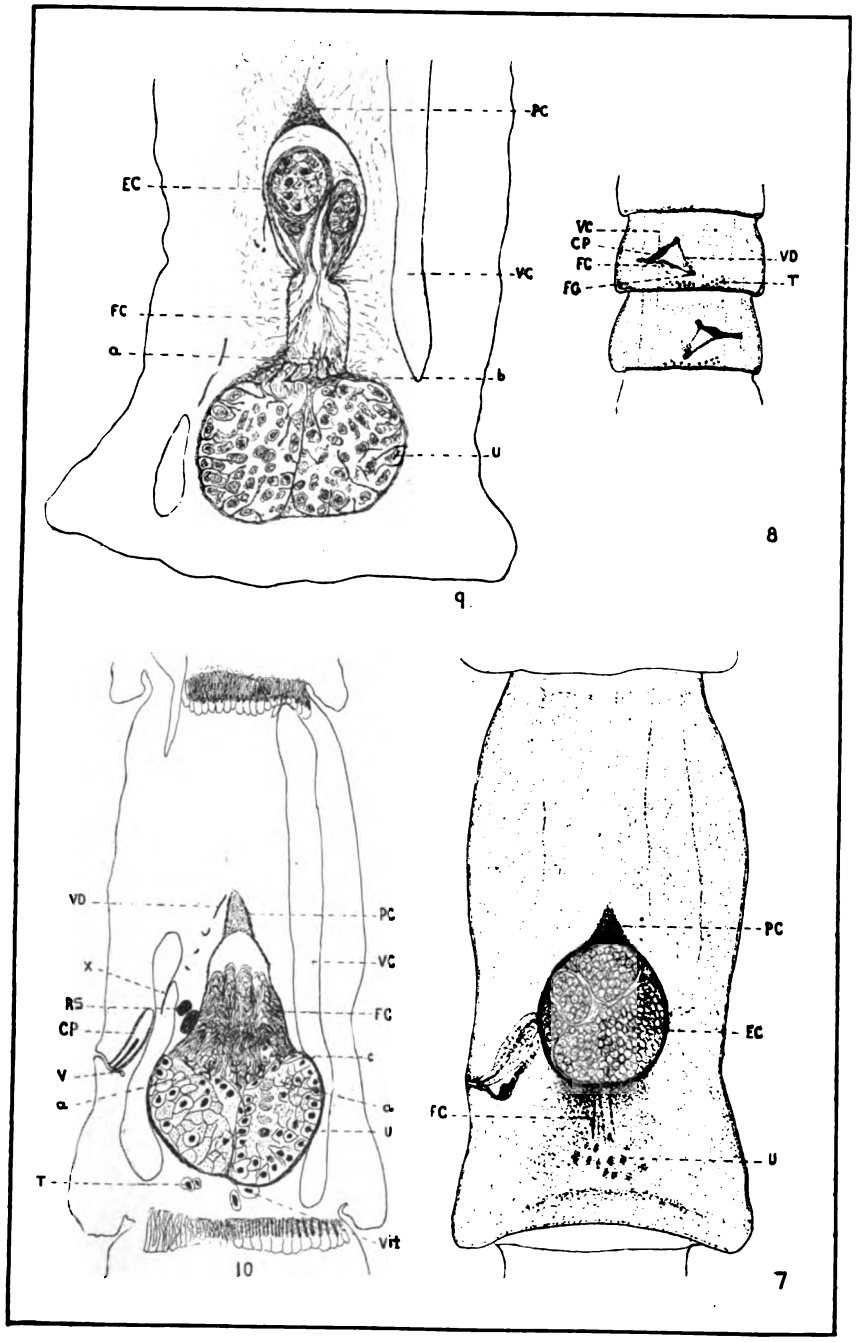
Digitized by Google

PLATE XIII



Digitized by Google

PLATE XIV



Digitized by Google

Digitized by Google

A COMPARATIVE STUDY IN METHODS OF PLANKTON MEASUREMENT.

By HENRY B. WARD,

ASSISTED BY H. W. GRAYBILL AND OTHERS.

WITH PLATES XV, XVI AND XVII.

INTRODUCTION.

During the course of a biological investigation on Lake Michigan in the Traverse Bay region, carried out under the auspices of the Michigan Fish Commission, a series of about one hundred plankton hauls was made in Lake Michigan and in the adjoining Round and Pine Lakes. These were taken between August 11 and 28, 1894, and are more fully described and located in a previous paper (Ward, 96b). A few of these hauls were measured within a short time after being taken, and some preliminary experiments on the details of the method to be used were made between November, 1894, and February, 1895. These were not employed in the subsequent discussion of the results of the work, for frequent interruptions made it difficult for me to follow a uniform system of measurement and in February, 1895, I secured the cooperation of one of my assistants, Miss Anna Fossler, who daily at a given time set some hauls each in a settling tube, from which the amount was read off after a lapse of exactly twenty-four hours. All of the readings in this series were verified by me at the time of recording them and were used in the papers (96-96b) on the results of the work. Consequently this series is designated as the original one (0, Pl. XV-XVII).

It was noticed, however, that the amounts obtained did not agree exactly with those recorded for certain hauls in the pre-

Digitized by Google

liminary experiments and more than a year and a half later Miss Fossler at my request repeated the measurements in the same tubes and as nearly as possible in the same manner as before. This second set of gravity measurements was made between December 26, 1896, and January 16, 1897, and is designated as the first supplementary set (1, Pls. XV-XVII). During some work on the Great Lakes the following year I became impressed with the advisability of careful, comparative measurements on a series of plankton hauls as a means of determining the various errors and variations to which the method was subject; and at my request Miss Fossler again repeated the measurements. This, the third set of gravity measurements, was made between August 19 and September 7, 1898, and is designated as the second supplementary series (2, Pls. XV-XVII). It was made thus more than three years after the original series, and was the last made by this method. It should further be noted that all three sets of gravity measurements were made not only in the same manner and with the same apparatus, but also by the same person. Any differences which may be found will therefore indicate those variations normal to the method.

It seemed also of importance to have for comparison a series of measurements of the same plankton hauls by means of the centrifuge which has been in use in a number of places in such work.* And in April, 1899, my assistant, Mr. J. A. Britton, measured the set of plankton hauls in a Bausch & Lomb Urine Centrifuge. The plankton was settled in the ordinary sedimentation tubes, being kept in revolution one minute, during which time the crank was given eighty complete revolutions. This first series of centrifuge measurements is designated as the third supplementary set (3, Pls. XV-XVII). The fourth sup-

* Juday (97) was apparently the first to publish an account of the use of the centrifuge for this purpose. Both Dr. Kofoid and I had, however, experimented independently for more than a year before that and had written to various investigators regarding the advantages of such an instrument.

Digitized by Google

plementary set (4, Pls. XV-XVII), which is the second series of centrifuge measurements, was made in January, 1900, by Mr. H. W. Graybill, who became much interested in the problem and performed all the extended and tedious mathematical operations necessary to reduce the volumes obtained to common terms with those used in the original paper (Ward, 96b). He also made the plates accompanying this paper and participated in the general discussion of its various points towards which he contributed items of value. While we were discussing the comparative results of the first and second sets of centrifuge measurements during the interval of the delayed appearance of this paper, Mr. Graybill suggested that as three sets had been made by the gravimetric method, a just comparison could only be made were there three sets of centrifuge measurements as well, since the chance of departure from the mean is evidently less in a double than in a triple set. He made then (April, 1900) a third set of centrifuge measurements which was added to the charts (5, Pls. XV-XVII) and text. The results of this set abundantly justified his prediction for after all possible care to make the measurements uniform throughout, combined with some skill in the use of the method, it was found that the measurements of the third set made by the centrifuge fell more frequently outside than within the limits of the first two sets made by the same instrument, as is distinctly shown on the plates. In all the centrifuge measurements the same instrument was employed and the same method followed in detail. Some experiments were tried in varying the conditions, particularly of time, but extended tests could not be made.

It should be noted further that all records were made and entered without any knowledge of former results or comparison with them, and the time interval was sufficient to preclude the possibility of remembering previous figures so that the estimation of the amount was made in an entirely unprejudiced manner. No haul was omitted because it seemed to "spoil the average" and the few gaps in the record are due to the accidental destruction of a haul, or to its utilization at an earlier date for other purposes (Ward, 96a).

Digitized by Google

While the senior author is alone responsible for the text of the paper, his sincere thanks are due to those who have cooperated so kindly in the accumulation and elaboration of the data on which it rests. Mr. Graybill has also participated in the discussion which has reduced the paper to its final form.

ERRORS IN PLANKTON DETERMINATION.

Quantitative determinations of the amount of floating organisms in fresh water have been made in various parts of the world and the methods and apparatus employed therein have been noticeably different. These investigations were summarized in a previous paper (Ward, 99) and need not be considered further here. Several investigators have called attention to various points of weakness in the methods and to the difficulty or impossibility of comparing results obtained under such radically different conditions. But so far as I know no one has yet endeavored to ascertain the limit of accuracy in these determinations, and the means by which different sets of observations may be reduced to common terms for comparison. It is my purpose to offer here some data towards the solution of this important question.

The accuracy of a plankton determination is of course dependent upon the accuracy of the various stages in the process so that the latter must necessarily be subject to analysis at first. One may readily distinguish four chief stages in the method: a) the process by which a certain quantity of plankton is obtained; b) the treatment involved in the permanent preservation of the quantity obtained; c) the determination of the volume obtained; and d) the enumeration or estimation of the individuals in this volume. A number of subordinate steps may be distinguished under each chief division of the process noted, as will appear later.

An extended discussion of the first question: Does the method employed in obtaining the plankton actually catch all the planktonts, has been given by Kofoid (97a) who emphasizes the loss incurred by the use of the vertical net and the advan-

Digitized by Google

tages accruing from the employment of a plankton pump. The disadvantages of the latter in cost, weight and lack of wide applicability have been urged by Reighard (98) and Fuhrmann (99). The use of the vertical net will evidently be more satisfactory when its actual efficiency as a catching apparatus has been determined by precise and full experimentation. Now it can only be said that the loss is real, considerable in some groups, and though perhaps numerically large, yet probably volumetrically small. Much more important it is to determine whether this loss is constant or variable, and if the latter under what conditions or in what way it varies. These questions have been discussed at length by various authors, but as yet no data are at hand which can be said to settle the matter definitely. For not only do opinions differ widely as to the possibility of determining the coefficient in a given net and as to its constancy under various circumstances, but there is also no basis for comparison between the efficiency of different nets and consequently no idea can be given as to the relative meaning of results obtained by different observers. They stand absolutely isolated and unrelated. It is important to establish the actual variation in a given net, and then to standardize the net by comparison with some other net having a known catching value or with some normal unit to be chosen. This is evidently necessary before it will be possible to compare results obtained by various investigators in different parts of the world.

On the second question as to whether any part of the catch is lost in subsequent manipulation, no precise calculations have been published. Careful observations made at Charlevoix by Dr. Kofoid at my suggestion failed to reveal any measurable loss of material during preservation of the hauls made there (Ward, 96) and improvements of the method introduced since then (Kofoid, 97) by which the plankton is transferred directly from the bucket of the net to the bottle in which it is preserved, tend to reduce to the minimum the loss of plankton during the process of preservation. There is, then, I believe reason for disregarding this possible error as inconsiderable in amount.

Digitized by Google

On the question of the determination of the plankton volume it may be said that the plankton hauls taken in fresh water have generally been measured volumetrically either by settling in a graduated tube or by the use of a centrifuge. Although the probability of variation in the first has been marked by nearly every author who has employed the method, no one has yet so far as I know given data to fix the amount of such variation under different conditions or to render possible a comparison of amounts obtained by gravitation with others measured in the centrifuge. The extensive series of measurements referred to in the introduction throws some light on this question in its various aspects.

First may be discussed the evidence as to variations in the measurement of plankton by settling, i. e., in the gravitation method. No hauls were measured absolutely fresh but a set of seven were permitted to settle in graduated tubes within 46 hours of the time they were taken. So far as these are concerned four were larger and three smaller than any subsequent measurements of the same hauls made by the gravitation method.*

In the first measurements of plankton hauls made by the gravity method during the winter following their being taken it was noticed that circumstances exercised a considerable influence on the result. The method followed involved the removal of a tube from the rack where it had stood, the notation of the volume and the return of the tube with all possible care to its place in the rack. If a reading of the amount was made after twenty-four hours and the tube returned to the rack where it had been standing, a second reading taken at a nominal interval thereafter would differ from the first. The difference

* At the time these were first measured I had not noted the effect of various factors mentioned below, so that there is no evidence that the measurements were made under identical circumstances. The absence of noteworthy difference merely favors the presumption that newly killed plankton does not behave differently from that which has been killed a much longer time. It should be said that the differences between the measurements of these hauls are greater in both directions than those recorded in other cases and greater than those listed for these same hauls later, due probably to lack of experience in the use of the method.

Digitized by Google

was naturally always a loss from the volume first noted and the figures given in the table following denote the number of cases for each error observed.

Loss at second reading	Less than 1 per cent.	1 to 5 per ct.	6 to 10 per ct.	11 to 15 per ct.	16 to 20 per ct.	Average per ct.
After an interval of 5 minutes...	1	8	5	0	0	5.5
10 " ...	0	0	2	4	0	10.0
15 " ...	1	10	8	4	1	7.0
20 " ...	1	1	1	1	0	5.5
40 " ...	0	0	1	2	0	14.0

A third reading still later than the above gave the following results. The time is recorded from the first reading which was in all cases twenty-four hours after the plankton tube was set aside to settle.

Af er an interval of	5 per ct. or less	6 to 10 per ct.	11 to 15 per ct.	16 to 20 per ct.	21 to 25 per ct.	Average loss per ct.
2 hours....	0	0	0	0	3	22.0
2 days.....	1	2	1	0	0	9.0
3 "	2	2	4	3	1	12.5
4 "	1	1	2	6	0	15.4
5 "	0	0	0	1	0	16.0
6 "	0	0	5	5	0	15.0
33 " . ..	0	3	1	0	0	9.5

The amount of reduction in any given plankton volume, measured by the gravity method, depends thus only very generally on the lapse of time, but is affected much more prominently by the disturbances to which the tube is subjected during the settling period. This is clearly shown by a series of measurements on the same plankton haul, left standing for some time and measured at varying intervals, at each of which the tube was moved as above.

	20 min.	4 days	5 days	6 days	6¼ days
Loss per cent. in volume.....	9	15	16	18	20

	15 min.	21 days	22 days	43 days
Loss per cent. in volume...	8	4	9	11
	3	6	7	8

Numerous experiments were made with the plankton hauls to determine the difference in volume dependent upon length

Digitized by Google

of time when the settling progressed undisturbed. Thus one series of tubes was left twenty-four hours and after the volume was recorded, thoroughly shaken and permitted to stand undisturbed either twenty-four or forty-eight hours longer with the following results based on comparison with original measurements of same.

Loss	Less than 1 per cent.	1 to 5 per ct.	6 to 10 per ct.	11 to 15 per ct.	16 to 20 per ct.	Average per ct.
Tubes standing 24 hrs.	4	6*	0	0	1*	+2
" " 48 "	0	8	4	0	0	—5

* One case under each starred column denotes a gain; all others indicate a loss of percentage given as compared with the first determination.

The longer settling period without disturbance results thus in a slightly diminished volume, but, as comparison with previous tables shows, the diminution is much less than if the tubes had been disturbed during the settling.

This was further illustrated by the effect of the location on volume; such tubes as were left on a table subject to vibration settled more compactly than the same hauls left an equal time in a position free from vibration.

The size of the settling tube has also a marked influence upon the amount obtained. Kofoid (97, p. 19) mentions the use for small planktons of a tube 6 mm. in inside diameter whereas those in ordinary use were 10 mm. in inside diameter. In the first measurements we used tubes of two diameters, 8 mm. and 10 mm., until remeasurements of the planktons originally tried in the smaller tubes showed a loss of 30 per cent., whereupon larger tubes, about 15 mm. in diameter, were also used for comparison. Four planktons were measured in the ordinary tubes and then in 15 minutes remeasured; the loss was 3, 4, 2, 3 per cent. respectively. The same planktons were then poured into a broad tube and after 21 days the volumes measured differed from these first taken in the ordinary tubes by -9, 0, -2 and 1 per cent.; in 22 days the figures stood -14, -4, -11, -14 per cent., and in 55 days -23, -11, -19, -20 per cent. Of another four two were left in the same tubes and two others changed to broad tubes with the following results:

Digitized by Google

Plankton measured after 24 hours	Loss in 15 minutes	The plankton was then	Loss per cent. after 21 days	22 days	48 days	55 days
8.90 cc.	3 per cent.	Kept in same tube	4	9	11	
8.55 cc.	3 per cent.		6	7	8	
9.82 cc.	6 per cent.	Transferred to large tube	1	7	13	19
9.70 cc.	5 per cent.		2	10	20	27

These data show again that the reduction in volume is consequent upon handling or disturbance rather than upon time of settling and apparently also that the loss in volume was somewhat greater in the larger tubes, other conditions being apparently identical.

Regarding the personal equation in such measurements, the following data are given: A total of 50 hauls was measured by Miss Fossler and myself independently and within a short time of each other. The average variation was 3.6 per cent.; a variation of more than 20 per cent. occurred in 2 cases, of 10-20 per cent. in 20 cases, of 5-10 per cent. in 11 cases, of less than 5 per cent. in 17 cases, in three of which the amounts obtained were actually identical. These results may now be compared with those obtained at widely separate time intervals by the same person. For such comparison in the gravimetric method three sets of figures, made from the same hauls at intervals of a year and a half, are given in the original and first and second supplementary sets, and their comparison yields the following table:

Compared with the first	Gain 10 to 15 per ct.	Gain 5 to 10 per ct.	Gain 1 to 5 per ct.	Same	Loss 1 to 5 per ct.	Loss 5 to 10 per ct.	Loss 10 to 15 per ct.	Loss 15 to 20 per ct.
The second measurement shows the following cases.....	3	4	7	5	21	27	19	9
The third measurement shows	2*	9	13	8	27	17	12	6
Total cases.....	5	13	20	13	48	44	31	15

These figures seem to indicate a slight average reduction in amount with time and yet the third series was measurably larger than the second though made a year and a half later.

* One case 60 per cent. gain was evidently due to an error in reading or recording.

Digitized by Google

When it is considered that out of 196 cases in all, 81 or nearly half vary less than 5 per cent. either way in three successive measurements and 57 more fall within the 10 per cent. limit, leaving a total of 58 or between one-third and one-fourth all of which however come within the 20 per cent. limit, it may fairly be claimed in view of the actual variations in the plankton itself that the results obtained in this way by the gravimetric method are comparatively uniform for the same haul.

If however different hauls, and especially those containing different kinds of plankton organisms, be compared, the results are otherwise. On this point Kofoid says (97, p. 19): "Planktons do not settle to an equal density. Those composed of Rotifera or small Cladocera (as *Chydorus*) pack closely, while others containing filamentous forms, as *Oscillaria* or *Fragilaria*, and those in which the larger Entomostraca are predominant settle very loosely. Thus the determination of the volume of the plankton by the settling method does not give a uniform test of the amount of plankton present. Furthermore the process is a tedious one, especially when large numbers of catches are to be handled."

With the latter statement, every one who has employed the gravimetric method on a considerable series of hauls will most heartily agree. The former is true whenever the hauls are commingled with any of the filamentous algae, but when these are absent it is only true within limits which are in fact less than the limits of normal variations in the amount of plankton.

These points are still clearer from an examination of the plates where the position of the lines indicates the relation of the various series of measurements. The fact that the three lines indicating the successive sets of gravimetric measurements cross and recross diverging and approaching indicates that one set of measurements does not show a constant loss or gain as compared with any other, such as might be due to gradual shrinkage of volume with time, or to any other single factor; but rather that the measurements vary indefinitely from one another.

Digitized by Google

Regarding gravimetric measurements in general it may be stated further that at least two factors, the diameter of the settling tube and the length of time during which the tube is left standing are entirely arbitrary. The former influences the volume considerably, the latter somewhat though not so noticeably as some external factors.

If now the results obtained by the gravity method and by the use of the centrifuge be compared with each other, as may be most easily done from the graphic presentation of results given in the plates, it appears first, as could have been predicted, that the amounts obtained by the centrifuge are constantly less than those measured in settling tubes. This is not only true of the amounts obtained by direct measurement (Pl. XV) but also of those representing the stratal volumes which are obtained indirectly. So generally is this the case that a few observations, such as XVIII (2, Pl. XVII) where one gravimetric value departs so widely from others obtained by the same method as to fall far below those measured in the centrifuge, impress one as distinctly erroneous and in all probability attributable to errors of notation. The amounts obtained by centrifuge measurement range from 30 to 40 per cent. of those recorded from the settling tubes for the same haul; the average being slightly more than one-third; the results differ, however, according as one series or the other be taken on either side as the basis of comparison. Juday (97) found that the centrifuge gave about one-fifth of the volume obtained by settling. His method varied in detail from that which we used, employing 100 revolutions of the crank in centrifuge measurements; no details are given regarding the precise method of gravity measurements.

In the next place it will be noted that the lines indicating the centrifuge measurements follow regularly those of the gravity measurements with but a single marked exception, that already noted as probably an error (Haul XVIII, 2, Pl. XVII); but that in general the variations of the centrifuge line are less violent. This is beautifully shown in a comparison of the lines

Digitized by Google

of total volumes (GT and CT, Pl. XV). For the sake of distinctness the latter were dropped 7 ccm. and were measured from the double line as a base. They stand thus everywhere clear of the lines (GT) portraying the results of the gravimetric method and while following in general the movements of the latter they do so everywhere with less intensity. The same appears from a comparison of the lines of average volume (GA and CA) on the same plate.

When the three sets of centrifuge measurements are compared to one another using the first as a basis, the following figures are obtained:

Compared to first	Gain of								Loss of						
	35 to 40 per ct.	30 to 35 per ct.	25 to 30 per ct.	20 to 25 per ct.	15 to 20 per ct.	10 to 15 per ct.	5 to 10 per ct.	No difference	1 to 5 per ct.	5 to 10 per ct.	10 to 15 per ct.	15 to 20 per ct.	20 to 25 per ct.	25 to 30 per ct.	30 to 35 per ct.
No. cases in second measurement...	4	3	4	4	16	18	18	2	10	5	9	1	3	1	0
No. cases in third measurement...	2	2	9	1	10	11	17	2	10	14	10	3	5	0	2

The average advance in the hauls showing a gain is 11.82 and 11.63 per cent., and the average reduction in hauls showing a loss is 10.62 and 11.41 per cent., results which are strikingly uniform.

If these results be compared with those obtained in the three gravity measurements, the first series by each method being taken as a basis for the computation of percentages in other series by that method, the methods show the following differences in the later series of measurements.

Digitized by Google

	Gravity measurement	Centrifuge measurement
Less than 5 per cent. difference, either more or less	84 cases	59 cases
From 5 to 10 per cent. difference, either more or less	57 "	48 "
More than 10 per cent. difference, either more or less	51 "	89 "
Total number	192 cases	196 cases

The decidedly better showing on the part of the older gravity method is certainly due in part to the smaller quantities obtained by centrifuge measurement and the consequent greater percentage of the whole which a minute difference constitutes. In actual amounts the centrifuge measurements were very close as shown by the following comparison of the second and third sets with the first.

	Second	Third
No. cases from 0.00 to 0.05 ccm. less or greater than in first,	27	34
" " " 0.05 to 0.1 " " " " " " "	33	23
" " " 0.1 to 0.2 " " " " " " "	15	21
" " " 0.2 to 0.2 " " " " " " "	9	11
" " " 0.3 to 0.4 " " " " " " "	3	4
" " " 0.4 to 0.5 " " " " " " "	7	2
" " " 0.5 to 0.6 " " " " " " "	0	0
" " " 0.6 to 0.7 " " " " " " "	1	2

Here 67 cases show a greater amount in the second measurement than in the first and only 26 a less; the measurements were made by different individuals, indicating a distinct though slight tendency on the part of the second experimenter to increase volumes either in reading amounts in the centrifuge tubes or in unconsciously modifying the process so as to secure a larger amount in fact through less condensation.

In the third the number of cases showing a greater amount than the first was only 54, a notable reduction from the condition in the second set of measurements, although the second and third sets were both made by the same individual. There is thus evident a slight variation in the results obtained by the same person at different times.

A general comparison of the value and utility of the two methods of measurements suggests the following. In settling

Digitized by Google

tubes a uniform density is certainly not obtained, for as both Kofoid and I have noted, different plankton hauls settle so unevenly as to present to the eye regions of variable density in the graduated tube while in the centrifuge tubes no difference is apparent. The centrifuge affords certainly a more speedy and more easily manipulated method, one that does not depend at all so far as observed on environment, i. e., external vibration, handling of tubes, etc., and one which furthermore is not so liable to accident as in the case of long settling tubes standing full for twenty-four hours. Owing to the peculiar conical tip of the centrifuge tube a small quantity may be more precisely estimated than one which is larger and hence is open to less percentage of error than if measured in a settling tube of approximately equal calibre throughout. Finally it is indisputable that with the centrifuge conditions may be much more precisely stated in measurable terms, and consequently repeated by other observers with a greater chance of obtaining similar conditions and hence results directly comparable. In fact I may confess that I entered upon the final comparison with a distinct prejudice in favor of the centrifuge so strong that it has not been entirely removed by the apparently negative results of this series of observations, where, as noted above, the centrifuge measurements are not so close in percentage of volume as those made by the gravity method.

One recent writer (Fuhrmann, 99) refers to the centrifuge method as detrimental to the plankton if desired for future study. This is certainly not the case with the hauls used in these experiments; after six years' time and all the manipulation noted the various planktonts are apparently as good for microscopic study or for numerical estimation as they were at the start. Dr. Kofoid informs me in correspondence that his experience with plankton hauls measured in the centrifuge has been the same as mine.

Some experiments were conducted with the centrifuge to determine the influence of time of rotation on amount obtained. One dozen hauls, measured in one-half minute with 40 revolu-

Digitized by Google

tions of the crank, i. e., half the usual time and number of revolutions, yielded results which in 4 cases were less and in 7 cases more than the figures obtained in the regular series. The kind of plankton made so far as could be seen no difference in results and the size of tube used in measuring could not be varied in the experiments so that I am unable to say how, if at all, it influenced the results.

Finally one may inquire as to the question of paramount importance, how all the variations in each method and how the change of method would affect the general statements previously made regarding the distribution and relative mass of plankton in the various strata in Lake Michigan. In the original paper (Ward, 96b) it was said:

"1. The total volume increases with the depth but more rapidly for depths up to about 30 meters than beyond that point." This is illustrated in the lines CT and GD, Plate XV.

"2. The volume per cubic meter of water decreases as the water grows deeper. This decrease is irregular for shallower stations, but comparatively constant in deeper water." This is shown by the lines GA and CA, Plate XV.

"It is at once apparent that the surface stratum contains a much greater quantity than any other stratum, on the average more than twice as much, while the intermediate strata are not far from equal. * * * The line of volumes in the surface stratum, 0 to 2 meters (Plate XVI, B), pursues a somewhat irregular course. The irregularities are independent of the depth and of the total and relative volumes of plankton. * * The five to ten meter stratum contains more plankton per cubic meter of water than the two to five meter stratum."

The results of the six series of measurements given on the charts unmistakably show that whichever method or series be taken all statements made regarding the amount and distribution of the plankton hold good. All variations and errors are not enough to obscure or render doubtful the general relations between the amounts of plankton found in the various strata.

Of errors common to both methods there may be noted two: that of estimation, and that of notation, as they may be called.

Digitized by Google

Variations in measurements are thus sometimes brought about by the liability to personal error to which both methods are open. The upper surface of the plankton mass is uneven both in the settling tubes and in the centrifuge, and the estimation of the actual value involves a chance of error which is proportionately greater as the amount measured is less. It is often very difficult to estimate the mass, as when the upper surface is hollowed out. What the limits of this error may be I can not show, but they are probably narrow.

To this must be added the well known errors due to the use of figures. These are made in reading the scale and in recording the amounts. That such do occur, all who have tried either method are convinced and think that in them may be found the cause of isolated values far removed from those of the same haul in the other two or more sets of measurements. Such a case is apparently Haul XVIII (Pl. XVII) in which two values obtained by the gravity method are positive and in practical agreement, the third by the same method is negative and evidently imaginary.

In the light of the general close correspondence in the volume of a haul at different measurements by the same method, a difference of 60, or even of 37 per cent. as noted in two isolated cases can hardly be other than a mistake in reading or copying the amount observed. Each assistant has independently made mention of the likelihood of a slip of this character and of the difficulty of guarding against it entirely.

It should not be forgotten that there may be differences due to the actual loss of a quantity of material from a haul at one stage or another during the long drawn out period of manipulation. At the start there was no intention of using these records for comparative purposes, and losses, if any, occurring after a measurement was completed, were not recorded as they did not affect the series just made and other series were not planned until later. Such a hypothesis will match well one or two radical differences, shown on the plates, but in the absence of positive evidence it is enough to have referred to the possibility.

Digitized by Google

The fourth question propounded at the start: What is the error in the enumeration or estimation of the individuals in the volume obtained, may be only briefly touched upon as it was not included in the series of experiments which form the basis of this paper. Personally I feel that a mere tabulation of the number of individuals of given species in a given haul is of little value; it certainly misleads one as the different individuals are of enormously different quantitative value. Whipple (94b) has brought forward a method which does away to a large extent with the misconception aroused in that these values are expressed in terms of a given unit area. This is undoubtedly very helpful in many cases in arriving at a just idea of the relative importance of different species. On the whole, however, I am inclined to think that the general productivity of a lake will be expressed in the form of volumes as is the case with land surfaces. It would add nothing to our conception of the fertility of a field to state it in number of kernels rather than in bushels of corn or wheat; similarly the economic measure of a water basin will not be modified by the millions of bacteria it contains however much it may be dependant upon the same in ultimate biologic analysis. To this extent, then, I think the statements of Kofoid are apt to be misleading when he refers to the enormous number of minute planktonts which escape the meshes of the net. They are unquestionably important, their number should be determined and their part in the economy of the water clearly fixed, but they are still insignificant from a general standpoint.

The question of the extent to which enumeration should be carried, and above all that of the actual meaning of the results obtained needs careful elucidation. On this matter I have no data to offer here.

Field (98) maintains that volumetric estimation is indispensable and has made use of a large form of the centrifuge in the precipitation and measurement of living oceanic plankton. This form, known as the planktonokrit, was originally described by Dolley (96). While Field holds that the centrifuge is a rapid and accurate means of determining the plankton volume

Digitized by Google

he does not refer to the extent or character of the evidence on which such a view is based, and in a previous paper (Field, 97, p. 425) states that certain forms are packed more closely than others by centrifugal force, which would indicate another source of error in comparative estimations.

CONCLUSIONS.

1. Some part of the plankton is not caught in the vertical net since a) the latter does not filter the entire water column, and b) some organisms pass through its meshes. Neither factor has yet been precisionated. The amount and constancy or variability of this error should be precisely determined.

2. In manipulations incident to preservation the loss of plankton is insignificant.

3. In measuring plankton by the gravimetric method, the age of the preserved material is immaterial; the amount of disturbance to which the plankton tubes are subjected during settling is much more important in modifying the volume than the length of time they stand, and the diameter of the settling tubes influences strongly the results obtained.

4. Under similar conditions the results obtained by the gravimetric method are comparatively uniform for the same haul, but vary with the kind of plankton measured.

5. Measurements made with the centrifuge yielded volumes from one-third to two-fifths as large as those obtained by the gravimetric method.

6. In the series of measurements made, the centrifuge method showed greater variation than the gravimetric.

7. Both methods agree as to results in all essential points and no series of measurements vitiated or modified the statements regarding the general distribution of plankton in Lake Michigan as originally deduced from the hauls.

8. The centrifuge method appears to have greater general utility, and uniformity sufficient to call for its preference; with plankton hauls differing radically in composition it would probably be more uniform than the gravimetric.

Digitized by Google

9. It does not injure the most delicate material obtained.

10. Errors of estimation, of notation, and those due to actual loss, are likely to occur in any series of measurements.

11. Evaluation by volume furnishes more usable values than mere numerical estimation. The latter may be improved by areal estimation.

Zoological Laboratory,
The University of Nebraska.

LITERATURE CITED.

DOLLEY, C. S.
96. The Planktonokrit, a Centrifugal Apparatus for the Volumetric Estimation of the Food-Supply of Oysters and other Aquatic Animals.
Proc. Acad. Nat. Sci. Phila., 96, 276-289, 1 Fig.

FIELD, G. W.
97. On the Plankton of Brackish Water. (Abstract.)
Science, n. s., V, 424-425.

98. Use of the Centrifuge for Collecting Plankton. (Abstract.)
Science, n. s., VII, 201.

FUHRMANN, O.
99. Zur Kritik der Planktontechnik.
Biol. Centralbl., XIX, 584-589.

JUDAY, C.
97. The Plankton of Turkey Lake.
Proc. Indiana Acad. Sci., 96, 287-296, 1 map

KOFOID, C. A.
97. Plankton Studies. I. Methods and Apparatus in Use in Plankton Investigations at the Biological Experiment Station of the University of Illinois.
Bull. Ill. Lab. Nat. Hist., V, 1-25, 7 Pls.

97a. On Some Important Sources of Error in the Plankton Method.
Science, n. s., VI, 829-832.

REIGHARD, J. E.
98. Methods of Plankton Investigation and their Relation to Practical Problems.
Bull. U. S. Fish Comm., XVII, 169-175.

WARD, H. B.
96. The Food Supply of the Great Lakes, and Some Experiments on its Amount and Distribution.
Trans. Amer. Mic. Soc., XVII, 242-254, 2 Pls.

Digitized by Google

96a. A New Method for the Quantitative Determination of Plankton Hauls.
Trans. Amer. Mic. Soc., XVII, 255-260.

96b. A Biological Examination of Lake Michigan in the Traverse Bay Region.
Bull. Mich. Fish Comm., 6, 1-71, 5 Pls.

99. Fresh-Water Investigations During the Last Five Years.
Trans. Amer. Mic. Soc., XX, 261-286.

WHIPPLE, G. C.

94b. A Standard Unit of Size for Micro-Organisms.
Amer. Mo. Mic. Jour., XV, 377-381, 2 Figs., 1 Pl.

EXPLANATION OF PLATES.

Vertical lines indicate stations, each of which is designated by a Roman numeral at the upper end.

Horizontal lines represent volumes or depths, each square indicating ten meters in depth or one cubic centimeter in volume, the total being reckoned from the upper margin of the chart, except for CT (q. v.).

D....D indicates depth of the various stations.

GT....GT represents total volume of plankton measured by the gravimetric method.

CT....CT indicates total volume of plankton measured by the centrifuge. The volume is here reckoned from the double line near the middle of the chart as a base rather than as all others from the top line of the chart.

GA....GA represents estimated volume of plankton per cubic meter of water measured by gravimetric method.

CA ...CA represents estimated volume of plankton per cubic meter of water measured by centrifuge.

0. Original set of measurements, made by gravimetric method.
1. First supplementary set by gravimetric method.
2. Second supplementary set by gravimetric method.
3. First set of measurements made by centrifuge.
4. Second set of measurements made by centrifuge.
5. Third set of measurements made by centrifuge.

For further details see text; also Ward, 96, 96b.

Digitized by Google

PLATE XV.

A GRAPHIC REPRESENTATION OF AMOUNTS IN BOTTOM HAULS FROM LAKE MICHIGAN MADE WITH VERTICAL NET.

PLATE XVI.

A GRAPHIC REPRESENTATION OF STRATAL HAULS.

A. Stratum 25 meters to 10 meters.
B. Stratum 2 meters to surface.

PLATE XVII.

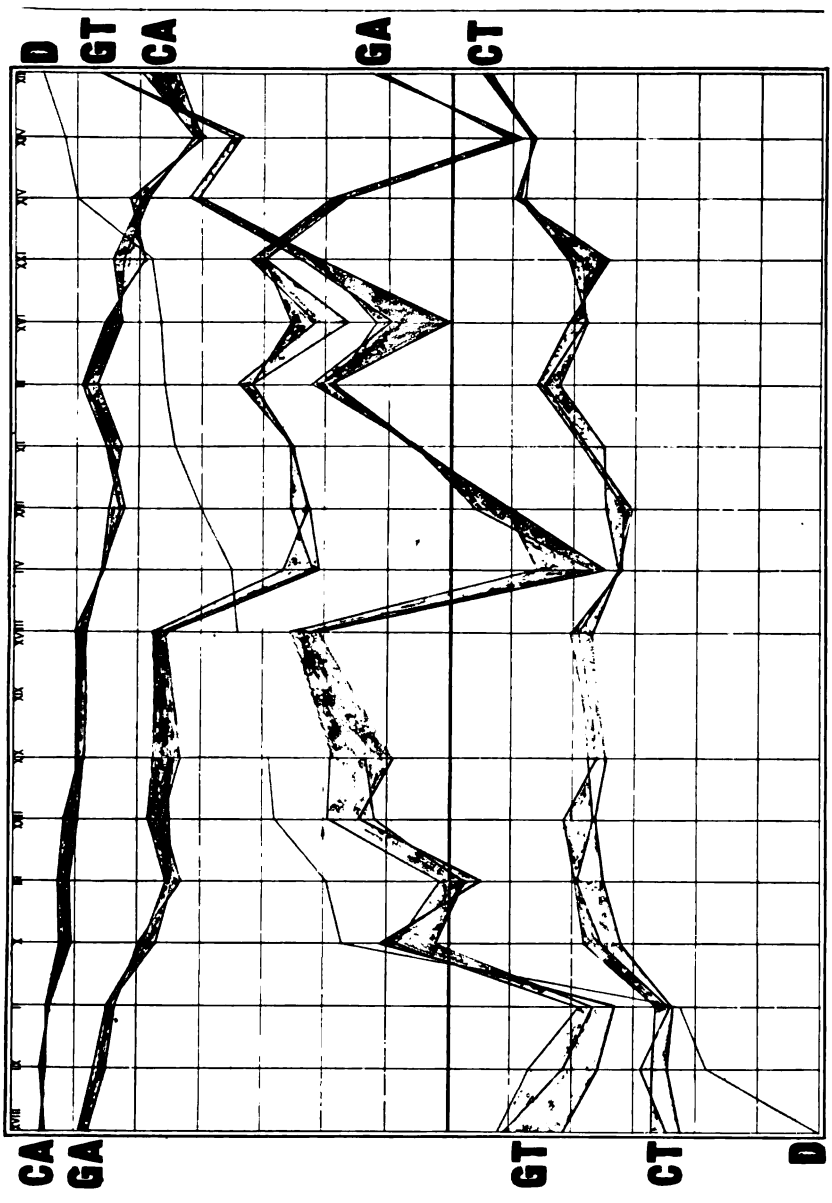
A GRAPHIC REPRESENTATION OF STRATAL HAULS.

A. Stratum 5 meters to 2 meters.
B. Stratum 10 meters to 5 meters.

Digitized by Google

Digitized by Google

PLATE XV

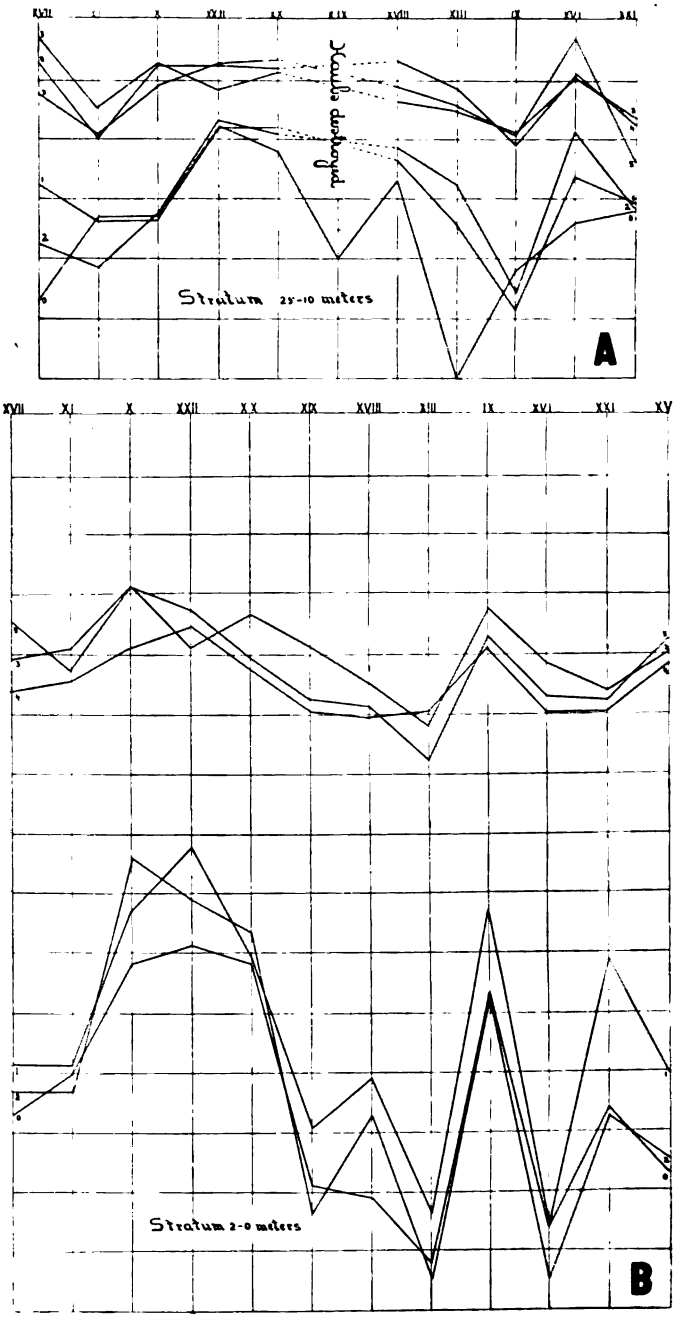


Digitized by Google

Digitized by Google

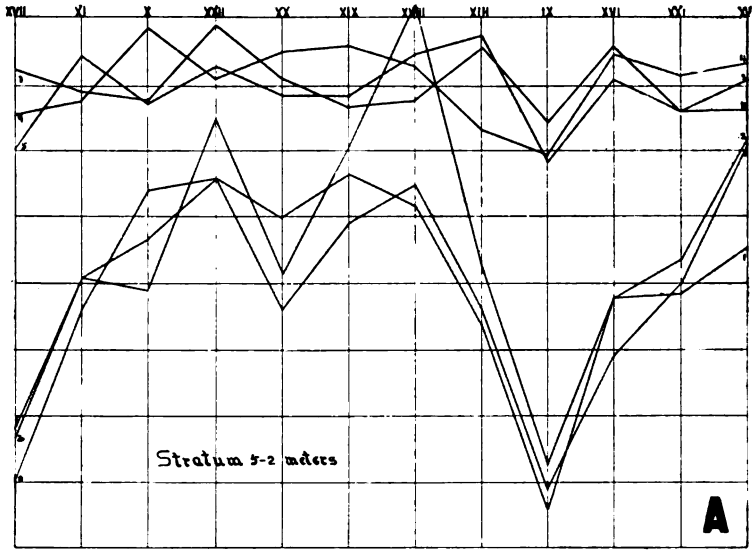
Digitized by Google

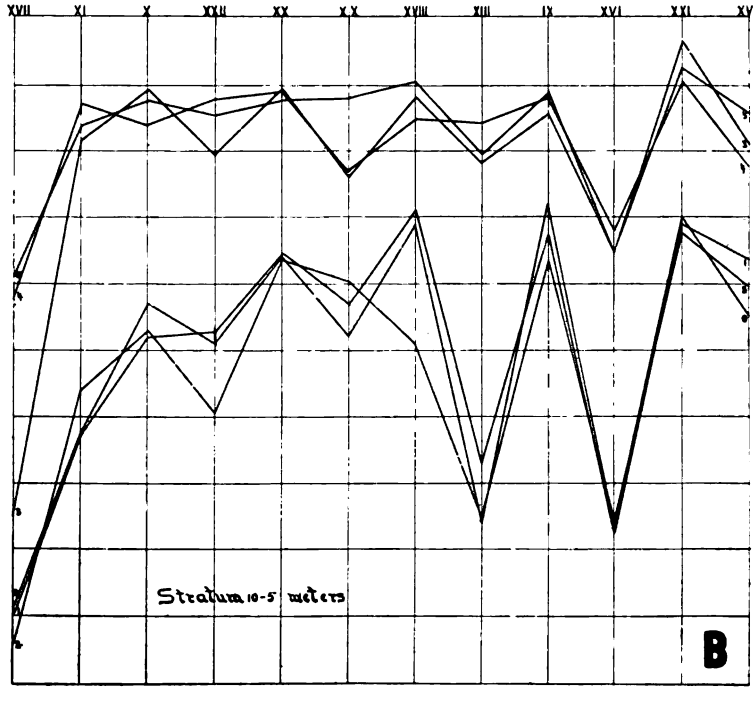
PLATE XVI



Digitized by Google

PLATE XVII





Digitized by Google

Digitized by Google

NECROLOGY.

JOHN EUGENE DAVIES,

OF MADISON, WIS.

John Eugene Davies was born in Clarkstown, N. Y., on April the 4th, 1839. When he was two years old his parents moved to New York City, remaining there till 1855. They then removed to Wisconsin.

In 1859, young Davies entered Lawrence University at Appleton, Wisconsin, as a Sophomore, graduating three years later, with honors in mathematics.

The study of medicine, then begun by him, was interrupted by Lincoln's call for "300,000 more." Enlisting at once he served through the war without a day's furlough. Of his war experiences he rarely if ever talked, seeming to have a horror of it all. I have heard him speak most strongly of war's brutalizing influences.

After the war he resumed the study of medicine, graduating from the Chicago Medical College in the Spring of 1868. In the Fall of the same year, he accepted a call to the chair of Natural History and Chemistry in the University of Wisconsin. In 1874 he became Professor of Astronomy and Physics; in 1878, Professor of Physics; in 1891, Professor of Electricity and Magnetism and Mathematical Physics. This chair he held until his death. During the interim between the resignation of Prof. Holden and the appointment of Prof. Comstock, Dr. Davies had charge of the Washburn Observatory.

Many of his summers were spent in the geodetic survey of Southwestern Wisconsin, he having charge of a party of the U. S. Coast Survey.

Digitized by Google

He was a member of the Wisconsin Academy of Sciences, Arts, and Letters and of the American Mathematical Society.

He was married in 1866 to Miss Anna Burt, of Chicago. Some years after her death he was married to Miss Olive M. Thayer, of Madison. A child by his first wife died in infancy. His second wife and her child survive him.

Such is the brief outline of his busy life. In it there is evidence of versatility. Those, however, who had the good fortune to be under him and to work with him know how much more he was than versatile. His breadth of perception and keenness and justness of vision were alike remarkable. He was an inspiring teacher, and many, I among them, owe to him a first start in what was to become a life's work; more than that, owe to him, indeed, their ideal of what a teacher should be. Enthusiastic in his subject, he was yet kind and patient with the student, always ready to explain difficulties and to suggest further lines of work.

In a day when the mere specialists are crowding us on every hand, pleasant is it to bear in mind one who, though a specialist, was none the less a many-sided man, with warm sympathy for all science, for all truth, for all that is highest and noblest and best in human achievement and ideals.

ELLERY W. DAVIS.

Lincoln, Neb., May 23, 1900.

HENRY H. DOUBLEDAY,

OF WASHINGTON, D. C.

On Sept. 19, 1899, the American Microscopical Society lost one of its most efficient members. Mr. Doubleday was first observed to be ill on Sunday evening, Sept. 17, during a meeting of one of the musical organizations with which he was connected, and soon after was removed to Garfield Hospital, where he died on Tuesday evening.

Mr. Doubleday was born in Binghampton, N. Y., sixty-five years ago, and came to Washington in 1864, securing employ-

Digitized by Google

ment first in the navy yard, later in the Post Office Department, which after about five years of service he relinquished to engage in soliciting patents. In this business he was quite successful, and found leisure to identify himself with the life of the city as scientist, musician and philanthropist. Few men have such capacity as Mr. Doubleday possessed for interesting young people in scientific pursuits and the exercise of their intellects on subjects that tend to elevate and dignify character, and his influence in this way was of great value to the community. He promoted numerous clubs for mutual improvement, many of whose members received very substantial benefits from such connections, and his assistance was always generously given to all who showed themselves in any way worthy of it. Among these voluntary societies, one for the use of the microscope as applied to biology was an especial favorite with him. He accumulated quite a large library of scientific and especially of musical works, the use of which was always freely granted to his young friends. Probably most of the members of the Society who attended the Washington meeting of our Society will remember the activity and energy he displayed in furthering the objects of the meeting.

In 1858, Mr. Doubleday married Frances G. Shepard, who survives him. His death leaves a vacant place in our community that cannot readily be filled, because his life was an example of unselfish work for the uplifting of others in all directions that tended towards their best interests.

WM. H. SEAMAN.

ALBERT E. LOVELAND,

OF WAVERLY, MASS.

Albert E. Loveland, M. A., M. D., was born in New Haven in 1868. He received his education in the public schools, graduating from Hillhouse High School in '87. Two years later he entered Wesleyan University, obtaining the degree of A. B. in '93. The summer following his graduation was spent

Digitized by Google

partly in study at the Marine Laboratory at Cold Spring Harbor and in part at the World's Fair, Chicago, as assistant chemist to Professor Atwater in food analyses. The following year he was assistant in biology in the laboratory of Professor Conn at Wesleyan. He then entered the Medical Department of Yale University, graduating in '97 *cum laude*, also receiving the Keese prize for the best thesis. The following year was spent as junior assistant at the Worcester Lunatic Asylum and at the time of his death, April 7, 1899, he was serving in the same capacity at the McLean Hospital, Waverly, Mass.

Dr. Loveland was held in high esteem by those who knew him, both as a man and professionally. I quote from the last report of the Superintendent of McLean Hospital: "He gave unusual promise of success in the work which he had chosen for his professional career, for which he possessed admirable qualifications."

In 1897 Wesleyan conferred upon him the degree of M. A. for work done in comparative anatomy.

His more important papers were "On the Anatomy of *Taenia crassicollis* Rud." and "A Study of the Organs of Taste."

H. B. Ferris.

HERBERT R. SPENCER,

OF BUFFALO, N. Y.

In the death of Herbert R. Spencer, which occurred at Buffalo, N. Y., February 7th, 1900, American Microscopy has lost the last of its three famous workers to whose successful efforts in the development of microscope and telescope objectives the scientific world has acknowledged its indebtedness. His father, Charles A. Spencer, working under the greatest disadvantages, beginning to make lenses when he was a lad of but twelve years, seeking by laborious and painstaking efforts in the little country village where he lived, to make his own optical glass for his experiments, but fired with the spark of genius which

Digitized by Google

triumphed over every obstacle, succeeded by 1847 in making microscope objectives which accomplished results in definition that astonished the world and transcended the efforts of the most famous European opticians. He boldly grappled with the assertion of these savants that they had obtained "the largest angular pencil of light that can be passed through a microscope object glass" and demonstrated by actual construction that the angle of aperture in these higher power objectives could be greatly increased and with it their defining and resolving powers. His was the pioneer work that for the world developed the possibility of lens-making as applied to the microscope and led the way in the wonderful progress of that art which has marked the last half of the nineteenth century. His two pupils were Robert B. Tolles and Herbert R. Spencer, his son. The former died in 1898 and now the latter has ended his days in the prime of manhood and in the midst of an active and successful career in the field of labor that he loved and honored.

Herbert R. Spencer was born at Canastota, N. Y., November 1, 1849, and was one of six children. Two sisters and a brother survive him and his aged mother still lives. His education was that of the common schools, but his active mind was not content with what they had taught him and throughout his life he was an indefatigable reader and student. In boyhood he was fond of scientific study and work. He loved too the outdoor life of the woods and fields, and his fondness for hunting gave him that perceiving eye which sees so much that with less favored mortals escapes their sight. He was quite young when he began his pupilage in his father's shop at Canastota, but from the beginning he loved his work and was ambitious to excel in it. This made him an apt pupil and to a great degree he inherited his father's genius. They worked together in constant effort to improve what had already been accomplished and to develop new work of still greater perfection. After the partnership between Charles A. Spencer and A. K. Eaton which had been formed in 1854 was dissolved, Herbert Spencer became his father's partner in the optical business which was

Digitized by Google

carried on by them at Canastota until the autumn of 1873, when their shop was destroyed in a disastrous fire. Their tools and machinery which they had accumulated by many years of toil and saving were lost, as was all their finished work and much that was in process of making with their valuable records and drawings. It was a crippling blow but father and son plucked up their courage and taking a little barn for their workshop struggled along as best they could until 1875, when they left Canastota and connected themselves with the Geneva Optical Works at Geneva, N. Y. In 1877 they formed the partnership known as Charles A. Spencer & Sons which continued for three years. In these last three years of his life the father's health was failing and with waning vigor his own productiveness ceased, while that of his son Herbert increased with his increasing responsibilities and the new objectives of those years were the product of his own genius and skill. Several of these came into the hands of President Barnard of Columbia College, New York, who was one of the United States Commissioners to the Paris Exposition of 1878, and they were exhibited by him there with the happy result that the highest award of the Exposition—its large gold medal—was awarded to Charles A. Spencer & Sons for their superior excellence.

Charles A. Spencer died in 1881 and from 1880 until 1889 Herbert R. Spencer carried on the business of making microscopes, telescopes and their objectives under his own name at Geneva, N. Y., removing in the latter year to Cleveland, Ohio, where he established the H. R. Spencer Optical Company. In 1891 the Spencer & Smith Optical Company of Buffalo, N. Y., was incorporated and Buffalo became his home for the remaining years of his life. In 1895 the Spencer Lens Company was organized and bought out the Spencer & Smith Company. Herbert R. Spencer became the superintendent of its shops and found in its systemized business a larger and better field for his efforts than he had before known. He became warmly interested in developing and perfecting the several types of their well known Spencer microscopes and in largely increasing the line of their Spencer objectives and microscope accessories.

Digitized by Google

He was greatly interested in the wonderful developments of later years in optical science; the great variety in optical glass as produced at Jena gave him a broad field for his selection, of which he was quick to take advantage. He placed all his formulas in the hands of the Spencer Lens Company and taught skillful assistants to do the various processes of construction and correction which he himself had so laboriously learned, so that when he felt the approach of sickness in the autumn of 1899 he expressed his keen satisfaction that his work, so well begun, could be continued without difficulty in his absence. He had assumed a trust and was faithful to it to the end. He died at Buffalo, February 7, 1900.

At fifty years of age he was seemingly in the prime of a useful life too soon ended, and yet in his comparatively short career he had done much for science. By his genius, his tireless efforts and painstaking researches he accomplished results in applied optics which gave him rank with the foremost of the world's workers in that field, with Leuwenhoek, Amici, Hartnack, Zeiss and Abbé in Europe, with the elder Spencer and Tolles in America; accomplishments which have made possible the modern discoveries in medical science and hygiene with their beneficent life-saving results. Like his father he was ambitious in his work and critical of it; there was always in his own vision a better that mocked his best, and he was never satisfied until that better was secured and a better still beckoned him forward. He was most skillful in his manipulation as in formulating and the objectives made under his instructions at each step in his progress kept rank even-paced with the best of similar grades made elsewhere at the time. He was of a generous temperament towards others and never spoke unkindly of their work. To his friends whom he knew well there was a genial side to his personality which was very attractive. Towards others he manifested a quiet reserve but in all his relations of life he was modest and unassuming. His early death is a loss not only to his many friends but to the scientific world.

HENRY R. HOWLAND.

Digitized by Google

Digitized by Google

PROCEEDINGS

OF

The American Microscopical Society

MINUTES OF THE ANNUAL MEETING

HELD AT

COLUMBUS, O., AUG. 17, 18 AND 19, 1899.

THURSDAY, August 17.

The Society was called to order at 2:30 P. M. by the President, Dr. W. C. Krauss, in the lecture room of Biological Hall, Ohio State University. President Thompson of the Ohio State University delivered a most cordial address of welcome in behalf of the city and University, and Dr. Krauss responded as follows:

RESPONSE TO PRESIDENT THOMPSON.

"To you, President Thompson, and to the Ohio State University, the American Microscopical Society wishes to return hearty thanks for your kind words of welcome and for the privilege of meeting in this beautiful hall dedicated to the Sciences, of which we ourselves are devoted followers. This Society is not a stranger to the hospitality of your charming city, for on two previous occasions, in 1881 and 1888, we met within its borders; in fact Columbus enjoys the distinction—not of having discovered the Society—but of having been its host more times than any other city in the Union. The cause of this partiality I presume is due to the excellent care and kind hospitality afforded us during our brief stay among you.

Our meeting today, although looked forward to with much expectancy and pleasure, is unhappily marred by the remembrance that here on this very campus and within these walls

Digitized by Google

labored our dearly beloved friend and Ex-President, Professor D. S. Kellicott, one of the staunch supporters of our Society and one of its most honored members. His contributions to our Transactions since the foundation of the Society bear testimony to his scientific skill and acumen. His kindly words of greeting, his interesting and forcible discussions and his opinions and suggestions in our councils will be sadly missed. As a mark of esteem and of remembrance I will ask the Society to rise.

I also wish at this time to thank the Society heartily for the honor of having been chosen your presiding officer. Being compelled on account of severe illness to absent myself from the Syracuse meeting, I was thoroughly surprised when the daily papers announced the result of your election. The unexpected and unlooked for honor and the pleasure derived from your kindly remembrance acted as a powerful tonic and hurried convalescence to a fortunate termination.

Repeating the words of President Mercer at the Pittsburg meeting of "belonging to a profession that practices rather than preaches"—I declare this the twenty-second annual meeting of the American Microscopical Society open for the transaction of business."

The election of new members was followed by a report from the Executive Committee on the organization and work of the Society in which the following recommendation was presented:

"As a matter of general policy, whenever a special field of work within the province of the Society shall call for closer organization and more extended work, the Executive Committee favors the appointment of a committee which shall have charge of such work and shall endeavor to develop it. The Executive Committee therefore recommends the appointment of E. A. Birge, C. H. Eigenmann, C. A. Kofoid, H. B. Ward and G. C. Whipple as a Limnological Commission which shall strive to unify, extend and stimulate limnological work in this country, and shall present to this Society at its next annual meeting plans for the accomplishment of this end."

On motion the resolution was adopted.

Digitized by Google

The following papers were then read and discussed:

R. H. Ward, "An Expedient in Difficult Resolution." Discussion by S. H. Gage.

M. A. Veeder, "The Effect of Cancer on Defective Development." Discussion by Mrs. S. P. Gage, W. C. Krauss and others.

S. H. Gage, "Notes on Laboratory Technic." Discussion by Mrs. Gage.

H. B. Ward, "Comments on a Scientific Bibliography;" with this was presented a resolution which was by rule referred to the Executive Committee after discussion by S. H. Gage.

Vida A. Latham, "The Reaction of Diabetic Blood to Some of the Aniline Dyes." After being read by the President, in the absent of the author, it was also discussed by him.

F. W. Kuehne and J. C. Smith were appointed members of the Auditing Committee, and the Society adjourned.

At. 8 P. M. the Society convened in the same place to hear the annual address of the President, William C. Krauss, on "Some Medico-legal Aspects of Diseased Cerebral Arteries."

FRIDAY, August 18.

The Society was called to order in the Biological Hall at 10 A. M. by the President who appointed a Nominating Committee consisting of S. H. Gage, F. W. Kuehne, Magnus Pflaum, J. C. Smith and Mrs. S. P. Gage.

The following papers were then presented:

J. C. Smith, "Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana."

C. E. Bessey, "Modern Conception of the Structure and Classification of Diatoms." Discussed by S. H. Gage, Magnus Pflaum and Mrs. Gage.

W. F. Mercer, "Comparative Structure of the Soft Palate." In the absence of the author it was read by S. H. Gage, and discussed by W. C. Krauss, A. M. Bleile and H. B. Ward.

A. G. Field, "A New Microscope Stand." Discussion by S. H. Gage.

The society then adjourned.

Digitized by Google

At 2:30 P. M. the meeting was called to order by the President who announced as the subject of the symposium which was to occupy the afternoon session, "What can be done by the high school teacher and by the private worker with the aid of the microscope in various fields." A general introduction was given by S. H. Gage and the special topics treated as follows: B. D. Myers, Animal Histology; A. M. Bleile, Bacteriology; C. E. Bessey, Botany. The discussion was participated in by S. H. Gage, M. A. Veeder, A. G. Field, Magnus Pflaum, Mrs. Gage, A. M. Bleile, B. D. Myers, C. E. Bessey and others.

At 4:30 P. M. the Society made a tour of the University campus and inspected the various buildings, under the leadership of the Local Committee, A. M. Bleile and A. Feiel.

In the evening an informal reception was tendered the members of the Society and their ladies by Mr. J. F. Stone at his residence on East Broad Street. Mr. Stone described his trip down the Grand Canyon of the Colorado and exhibited a series of lantern slides made from the magnificent views taken *en voyage*. The general and spontaneous expression of pleasure and of indebtedness to their host showed the high appreciation in which members of the Society held the courtesies which had been extended to them on this occasion. The Secretary presented to Mr. Stone with the compliments of the Society a copy of the last annual volume of the Transactions as a token of the thanks of all for his general hospitality.

SATURDAY, August 19.

The Society convened at 9:30 A. M. in Biological Hall, President W. C. Krauss in the chair. The following papers were presented:

C. H. Eigenmann, "The Eyes of Typhlomolge from the Artesian Well at San Marcos, Texas."

B. D. Myers, "Method Employed in a Study of the Chiasma of *Bufo vulgaris*." This and the preceding paper were discussed together by S. H. Gage, W. C. Krauss and others.

R. H. Ward, "Indexing, Cataloguing and Arranging Microscopical Literature and Slides." This paper was very generally

Digitized by Google

discussed by the members present. Owing to the lateness of the hour the remaining papers were read by title and the Society took up business matters. After the election of new members, the annual report of the Treasurer was read and, being reported correct by the Auditing Committee, accepted. The Treasurer then stated that owing to various personal matters he felt compelled to tender his resignation to the Society. After many expressions of regret, the Society, voted in accepting the resignation, to place on record its appreciation of the long and faithful services which had been rendered for so many years by Mr. Pflaum, and its deep regret at his retirement from office.

The report of the Secretary was given and the Executive Committee authorized to make public the following memorial as an expression of the opinion of the Society:

"Some years ago the American Microscopical Society participated in the foundation of an enterprise which it may justly be said has grown to be of international importance, the Concilium Bibliographicum. Though the aid we could render to this organization was financially small, we have followed its development with genuine interest not unaccompanied by true pride in its successes and sorrow for its shortcomings.

"It was hoped that the movement would receive general approval and support, and that in the event of an extensive bibliographic undertaking on the part of any national society, all existing enterprises would be made use of.

"We have good evidence that the work of the Concilium Bibliographicum has been well done in the main and are convinced that the experience of its workers is invaluable for future work in this field since many of the problems which they have met and solved would recur in any new enterprise. We deprecate further the waste of energy for the development of science involved in the total abandonment of work done and of experience gained in the past and in the adoption of a new system which is apparently incompatible with that under which much has been accumulated.

"Knowing the efforts for the advancement of science in this particular direction at present, we therefore urge upon the con-

Digitized by Google

sideration of all the fundamental advantages in the utilization of the decimal system and of experience purchased with such earnest effort and great sacrifice."

The Nominating Committee reported the following officers for the ensuing year:

President.....A. M. Bleile
First Vice-President.....C. H. Eigenmann
Second Vice-President.....M. A. Veeder
Treasurer (for unexpired term).....J. C. Smith
Custodian.....Magnus Pflaum
Elective Members of Executive Committee..{ W. W. Alleger, A. T. Kerr, B. D. Myers

The report was adopted and the Secretary ordered to cast the ballot of the Society for the officers as named.

The Society passed votes of thanks to the Local Committee, to Mr. J. F. Stone, to the Ohio State University and President Thompson, to the local Press, and to the retiring President for courtesies extended to members in attendance at the meeting. The President-Elect was then escorted to the chair and after a few words of thanks to the Society declared the meeting adjourned.

During the afternoon the members were given a trolley ride about the city of Columbus by the local committee. After an enjoyable trip of a couple of hours the party sat down together to an informal luncheon under the auspices of these same enterprising members, to whom at its close all manner of thanks were extended by those who had enjoyed their hospitality.

HENRY B. WARD,
Secretary.

Digitized by Google

TREASURER'S REPORT

FOR THE YEAR ENDING AUGUST 17, 1899.

DR.

To Balance on hand at Syracuse Meeting.....		$ 78.48
To Membership dues, 1896, 1.....	$ 2.00	
To Membership dues, 1897, 1.....	2.00	
To Membership dues, 1898, 14.....	28.00	
To Membership dues, 1899, 188.....	376.00	
To Membership dues, 1900, 10½.....	21.00	
		428.00
To Admission fee, 1898, 1.....	3.00	
To Admission fees, 1899, 17.....	51.00	
		54.00
To Subscribers ($40, yet due $8).....		32.00
To Donation by Dr. C. E. Bessey for plates.....		23.50
To Sales of Proceedings ($66, yet due $2).....		64.00
To advertising ($96, yet due $12).....		84.00
To Postage and Expressage collected.....		.26
To Postage advanced by Mr. Pflaum, Treasurer.....		8.52
		$ 770.76

Digitized by Google

CR.

By Expense Syracuse Meeting		$ 4.05	
By Postage, Secretary	$ 14.42		
By Postage, Treasurer	15.95		
		30.37	
By Expressage, Secretary	86.80		
By Expressage, Treasurer	2.35		
		89.15	
By Stationery and Printing, President	6.75		
By Stationery and Printing, Secretary	27.78		
By Stationery and Printing, Treasurer	6.60		
		41.13	
By Stationery and Printing, Prof. S. H. Gage for 1898		5.00	
By Sundries, Secretary	11.20		
By Sundries, Treasurer	7.75		
		18.95	
By Issuing Vol. XX, printing	503.90		
By Issuing Vol. XX, plates	80.21		
		584.11	
By Spencer-Tolles Fund invested		48.00	
			$ 770.76

SPENCER-TOLLES FUND.

Reported at Syracuse Meeting	$ 555.46	
Jan. 2, 1899, Dividends	26.92	
July 1, 1899, Dividends	22.98	
Cash from Sale of Proceedings	48.00	
		$ 653.36
Increase during year		97.90

COLUMBUS, O., Aug. 18, 1899.

We hereby certify that we have examined the foregoing accounts for the year 1898 and 1899 and find them correct, with proper vouchers for expenditures.

F. W. KUEHNE,
J. C. SMITH,
Auditing Committee.

Digitized by Google

CONSTITUTION.

Article I.

This Association shall be called the American Microscopical Society. Its object shall be the encouragement of microscopical research.

Article II.

Any person interested in microscopical science may become a member of the Society upon written application and recommendation by two members and election by the Executive Committee. Honorary members may also be elected by the Society on nomination by the Executive Committee.

Article III.

The officers of this Society shall consist of a President and two Vice-Presidents, who shall hold their office for one year, and shall be ineligible for re-election for two years after the expiration of their terms of office, together with a Secretary and Treasurer, who shall be elected for three years and be eligible for re-election.

Article IV.

The duties of the officers shall be the same as are usual in similar organizations; in addition to which it shall be the duty of the President to deliver an address during the meeting at which he presides; of the Treasurer to act as custodian of the property of the Society, and of the Secretary to edit and publish the Proceedings of the Society.

Article V.

There shall be an Executive Committee, consisting of the officers of the Society, three members elected by the Society, and the past Presidents of the Society and of the American Society of Microscopists.

Digitized by Google

ARTICLE VI.

It shall be the duty of the Executive Committee to fix the time and place of meeting and manage the general affairs of the Society.

ARTICLE VII.

The initiation fee shall be $5.00, and the dues shall be $2.00 annually, payable in advance.

ARTICLE VIII.

The election of officers shall be by ballot.

ARTICLE IX.

Amendments to the Constitution may be made by a two-thirds vote of all members present at any annual meeting, after having been proposed at the preceding annual meeting.

BY-LAWS.

I.

The Executive Committee shall, before the close of the annual meeting for which they are elected, examine the papers presented and decide upon their publication or otherwise dispose of them.

All papers accepted for publication must be completed by the authors and placed in the hands of the Secretary by October 1st succeeding the meeting.

II.

The Secretary shall edit and publish the papers accepted with the necessary illustrations.

III.

The number of copies of Proceedings of any meeting shall be decided at that meeting.

Digitized by Google

IV.

No applicant shall be considered a member until he has paid his dues. Any member failing to pay his dues for two consecutive years, and after two written notifications from the Treasurer, shall be dropped from the roll, with the privilege of reinstatement at any time on payment of all arrears. The Proceedings shall not be sent to any member whose dues are unpaid.

V.

The election of officers shall be held on the morning of the last day of the annual meeting. Their term of office shall commence at the close of the meeting at which they are elected, and shall continue until their successors are elected and qualified.

VI.

Candidates for office shall be nominated by a committee of five members of the Society. This committee shall be elected by a plurality vote, by ballot, after free nomination, on the second day of the annual meeting.

VII.

All motions or resolutions relating to the business of the Society shall be referred for consideration to the Executive Committee before discussion and final action by the Society.

VIII.

Members of the Society shall have the privilege of enrolling members of their families (except men over twenty-one years of age) for any meeting upon payment of one-half the annual subscription ($1.00).

Approved by the Society, August 11, 1892.

Digitized by Google

LIST OF MEMBERS.

The figures denote the year of the member's election, except '78, which marks an original member. The TRANSACTIONS are not sent to members in arrears, and two years' arrearage forfeits membership. (See Article IV of By-Laws.)

Members Elected During the Year 1899.

For addresses see regular list.

BERING, J. EDWARD.
BEYER, Prof. GEO. E.
BIRGE, Prof. E. A., S. D.
BURCHARD, E. A., M. D.
COCKS, Prof. REGINALD S.
ELROD, Prof. MORTON J., M. A., B. A., M. S.
EYRE, JOHN W. H., M. D. Ph. D.
FISHER, Rev. STOKLEY S.
FOSTER, EDWARD.
FRAKER, H. C., M. D.
GROSSKOPF, ERNEST C., M. D.
HOLLIS, FREDERICK S., B. S., Ph. D.
JACKSON, DANIEL DANA., B. S.
KOFOID, CHARLES A., Ph. D.
MERCER, W. F.
PARKER, HORATIO N.
RANSOM, BRAYTON H.
RICHARDS, ELIAS.
SCHONEY, L., M. D.
TAYLOR, GEO. C.
THOMAS, ARTHUR H.
WEEKS, JOHN ROCKWELL.
WHIPPLE, G. C.

ABERDEIN, ROBERT, M. D., F. R. M. S., '82..327 James St., Syracuse, N. Y.
AINSLIE, CHARLES N., '92.....Rochester, Minn.
ALLEGER, WALTER W., M. D., '94....949 T St., N. W., Washington, D. C.
ATWOOD, E. S., '79.....261 West Thirty-fourth St., New York City.
ATWOOD, H, F., F. R. M. S., '78.....Rochester, N. Y.
AYERS, MORGAN W., M. D., '87.....Upper Montclair, N. J.

BARKER, ALBERT S., '97, Twenty-fourth and Locust Sts., Philadelphia, Pa.
BARNSFATHER, JAMES, M. D., '91.....
....Cor. Sixth Ave. and Walnut St., Dayton, Ky.
BARTLETT, CHARLES JOSEPH, M. D., '96.....New Haven, Conn.
BAUSCH, EDWARD, '78.....179 N. St. Paul St., Rochester, N. Y.
BAUSCH, HENRY, '86..... .....Rochester, N. Y.
BAUSCH, WILLIAM, '88.....Rochester, N. Y.
BEAL, Prof. JAMES HARTLEY, '96..... .....Scio College, Scio, Ohio.
BEARDSLEY, Prof. A. E., '97..... .....Greeley, Col.
BELL, CLARK, ESQ., '92.....39 Broadway, New York City.
BENNETT, HENRY C., '93.....256 W. Forty-second St., New York City.

Digitized by Google

BERING, J. EDWARD, '99.....Decatur, Ill.
BESSEY, Prof. CHARLES EDWIN, Ph. D., LL. D., '98..... Lincoln, Neb.
BEYER, Prof. GEO. E., '99..... Tulane University, New Orleans, La.
BIRGE, Prof. E. A., S. D., '99.....University of Wisconsin, Madison, Wis.
BISCOE, Prof. THOMAS D., '91.....404 Front St., Marietta, Ohio.
BLEILE, A. M., M. D., '81.... ...Ohio State University, Columbus, Ohio.
BODINE, Prof. DONALDSON, '96.....Crawfordsville, Ind.
BOOTH, MARY A., F. R. M. S., '82...60 Dartmouth St., Springfield, Mass.
BOYCE, JAMES C., Esq., '86.....Carnegie Building, Pittsburg, Pa.
BOYCE, JOHN W., M. D., '96.....23 Mawhinney St., Pittsburg, Pa.
BOYER, C. S., A. M , '92.....3223 Clifford St., Philadelphia, Pa.
BREDIN, GEO. S., '96.....302 Spitzer Building, Toledo, Ohio.
BROMLEY, ROBERT INNIS, M. D., '93.....Sonora, Cal.
BROWN, MISS L. S., '92.....W. Main St., Angelica, N. Y.
BROWN, N. HOWLAND, '91.....33 S. Tenth St., Philadelphia, Pa.
BROWN, ROBERT, '85.....Observatory Place, New Haven, Conn.
BRUNDAGE, A. H., M. D., '94..... 1153 Gates Ave., Brooklyn, N. Y.
BULL, JAMES EDGAR, Esq., '92.....141 Broadway, New York City.
BURCHARD, E. A., M. D., '99.....6 Elm St., Lodi, San Joaquin Co., Cal.
BURNER, NATHAN L., M. D., '96.....368 Hamilton Ave., Columbus, Ohio.
BURRILL, Prof. T. J., Ph. D., F. R. M. S., '78.... .....Urbana, Ill.
BURT, Prof. EDWARD A., '91.....Middlebury College, Middlebury, Vt.
BUSH, BERTHA E., M. D., '95.....808 Morse Ave., Chicago, Ill.

CAMPBELL, D. P., M. D., '88..Tomichi, White Pine P. O., Gunnison Co , Col.
CARPENTER, THOS. B., M. D., '99.....142 N. Pearl St., Buffalo, N. Y.
CARTER, JOHN E., '86..... ....
.....Knox and Coulter Sts., Germantown, Philadelphia, Pa.
CHESTER, ALBERT H., A. M., '88..Rutgers College, New Brunswick, N. J.
CLAPP, GEO. H., '86.....116 Water St., Pittsburg, Pa.
CLARK, GAYLORD P., M. D., '96.....Syracuse, N. Y.
CLARK, GEORGE EDW., M. D., '96.....Skaneateles, Onondaga Co., N. Y.
CLAYPOLE, AGNES M., '94.....Cornell University, Ithaca, N. Y.
CLAYPOLE, EDITH JANE, Ph. B., M. S., '93.....Ithaca, N. Y.
CLAYPOLE, EDWARD W., B. Sc., F. G. S., '86 ... .Pasadena, Cal.
CLEMENTS, FREDERICK E., A. M., Ph. D., '98.....Lincoln, Neb.
COBB, CHAS. N., A. M., '86.....26 N. Pine St., Albany, N. Y.
COCKS, Prof. REGINALD S., '99..McDonogh High School, New Orleans, La.
COOPE, A. F., M. D., '86.....114 Sycamore St., Oil City, Pa.
COUCH, FRANCIS G., '86. .. ..
Kalish Pharmacy, Twenty-third St. and Fourth Ave., New York City.
COX, CHAS. F., F. R. M. S., '85....Grand Central Depot, New York City.
CRAIG, THOMAS, '93..... .....244 Greenpoint Ave., Brooklyn, N. Y.
CUNNINGHAM, M. C., '96.....Board of Health, Pittsburg, Pa.

DAVIS, CHAS. H., '98..... ...Drawer 1033, Rochester, N. Y.
DAVIS, F. L., M. D., '99.....209 Locust St., Evansville, Ind.

Digitized by Google

DEAN, N. B. H., M. D., '96 .....Young St., Brighton, Ont.
DIDAMA, HENRY D., M. D., '96.... .....424 S. Salina St., Syracuse, N. Y.
DIEHL, ALFRED C., M. D., '96..... ...361 Pearl St., Buffalo, N. Y.
DORR, L. BRADLEY, A. B., M. D., '96.....800 Jefferson St., Buffalo, N. Y.
DORR, S. HOBART, Ph. G., '95.....945 Niagara St., Buffalo, N. Y.
DORT, MISS ELIZABETH, '96.....603 Fillmore Ave., Buffalo, N. Y.
DRESCHER, W. E., '87..... ...Box 1083, Rochester, N. Y.
DUNHAM, E. K., M. D., '92.....388 E. Twenty-sixth St., New York City.

EASTMAN, LEWIS M., M. D., F. R. M. S., '82.....
.....772 W. Lexington St., Baltimore, Md.
EIGENMANN, Prof. C. H., '95....University of Indiana, Bloomington, Ind.
ELLIOTT, Prof. ARTHUR H., '91.....4 Irving Place, New York City.
ELLIOTT, LUTHER B., '98.....4 Fulton Ave., Rochester, N. Y.
ELROD, Prof. MORTON J., M. A., B. A., M. S., '98.....
.....205 S. Fifth St., Missoula, Mont.
ELSNER, JOHN, M. D., '88 .....P. O. Box 454, Denver, Col.
ELWELL, A. T., '89.....16 Pearl St., Council Bluffs, Iowa.
EWELL, MARSHALL D., LL. D., M. D., F. R. M. S., '85.....
....618 and 619 Ashland Block, Chicago, Ill.
EYRE, JOHN W. H., M. D., Ph. D., '99.....
....Embankment Chambers, Villiers St., London, W. C., England.

FEIEL, ADOLPH, M. D., '81.....520 E. Main St., Columbus, Ohio.
FELL, GEO. E., M. D., F. R. M. S., '78.....72 Niagara St., Buffalo, N. Y.
FELLOWS, CHAS. S., F. R. M. S., '83..... ...
....28 Chamber of Commerce, Milwaukee, Wis.
FERRIS, Prof. HARRY B., '96.....118 York St., New Haven, Conn.
FIELD, A. G., M. D., '82.....Summit Place, Des Moines, Iowa.
FINDER, WM., Jr., M. D., '98.....2 Union Place, Troy, N. Y.
FISHER, MAX, '93.....Zeiss Optical Works, Jena, Germany.
FISHER, Rev. STOKLEY S., '99.....Pleasantville, Ohio.
FLINT, JAMES M., M. D., '91.....''The Portland,'' Washington, D. C.
FORDYCE, CHARLES, B. S., A. M., Ph. D., '98.....
.....Nebraska Wesleyan University, University Place, Neb.
FOSTER, EDWARD, '99.....P. O. Box 405, New Orleans, La.
FOX, OSCAR C., '92.... .....U. S. Patent Office, Washington, D. C.
FRAKER, H. C., M. D., '99.....342 Ohio Ave., Columbus, Ohio.
FULLER, CHAS. G., M. D., F. R. M. S., '81.....
.....89 Central Music Hall, Chicago, Ill.
GAGE, Prof. SIMON H., B. S., '82.....Cornell University, Ithaca, N. Y.
GAGE, MRS. SUSANNA PHELPS, '87.....Ithaca, N. Y.
GATES, ELMER, '96..... .....Chevy Chase, Md.
GOODRICH, W. H., M. D., '98.....Augusta, Ga.
GREEN, MISS ISABELLA M., M. S., '96...St. Mary's School, Raleigh, N. C.
GROSSKOPF, ERNEST C., M. D., '99.....Wauwatosa, Wis.

Digitized by Google

HAAG, D. E., M. D., F. R. M. S., '86..1121 Washington St., Toledo, Ohio.
HANAMAN, C. E., F. R. M. S., '79..... .....Box 527, Troy, N. Y.
HANKS, HENRY G., '86.....718 Montgomery St., San Francisco, Cal.
HATFIELD, JOHN J. B., '82.....883 Arsenal Ave, Indianapolis, Ind.
HEALD, GEORGE HENRY, M. D., '96.....St. Helena, Cal.
HEINEMAN, H. NEWTON, M. D., '91, 60 W. Fifty-sixth St., New York City.
HERTZLER, ARTHUR A., M. D., '96..... Halstead, Kan.
HIGGINS, F. W., M. D., '98.....Courtland, N. Y.
HILL, HERBERT M., Ph. D., '87.....24 High St., Buffalo, N. Y.
HOFFMAN, JOS. H., M. D., '96.....111 Steuben St., Pittsburg, Pa.
HOLBROOK, M. L., M. D., '82.....43 E. Twenty-first St., New York City.
HOLLIS, FREDERICK S., '99.....Newton Highlands, Mass.
HOLMES, A. M., M. D., '98.....Jackson Block, Denver, Col.
HOSKINS, WM., '79.....Room 55, 81 S. Clark St., Chicago, Ill.
HOWARD, CURTIS C., M. D., '88.....97 Jefferson Ave., Columbus, Ohio.
HOWLAND, HENRY R., A. M., '98.....217 Sumner St., Buffalo, N. Y.
HUMPHREY, Prof. O. D., Ph. D., '95 .....Jamaica, N. Y.
HYATT, J. D., '78.....69 Burling Lane, New Rochelle, N. Y.

JACKSON, DANIEL DANA, B. S., '99.....177 Sixth Ave., Brooklyn, N. Y.
JAMES, BUSHROD W., M. D., '94,..... .....
. .....N. E. cor. Green and Eighteenth Sts., Philadelphia, Pa.
JAMES, FRANK L., Ph. D., M. D., '82. .....Box 568, St. Louis, Mo.
JAMES, GEO. W., '92 .....108 Lake St., Chicago, Ill.
JOHNSON, FRANK S., M. D., '93.....2521Prairie Ave., Chicago, Ill.
JOHNSON, WM. D., M. D., '96.... .....Bergen, N. Y.
JOHNSTON, LEVI D., M. D., '96.....Whittier, Cal.
JONES, MRS. MARY A. DIXON, M. D., '98,..... .....
....249 E. Eighty-sixth St., New York City.

KELLOGG, J. H., M. D., 78..... ....Battle Creek, Mich.
KERR, ABRAM TUCKER, JR., '95.....1386 Maine St., Buffalo, N. Y.
KINGSBURY, BENJ. F., A. B., M. S., '94..... .....Ithaca, N. Y.
KIRKPATRICK, T. J.,'93.....Springfield, Ohio.
KLINE, A. T., '97.....385 Superior St., Toledo, Ohio.
KOFOID, CHARLES A., Ph. D., '99 ....Urbana, Ill.
KOTZ, A. L., M. D., '91..... .....53 S. Fourth St., Easton, Pa.
KRAFFT, WILLIAM, '95.....411 W. Fifty-ninth St., New York City.
KRAUSS, WM. C., B. S., M. D., F. R. M. S., '90... ....
....871 Delaware Ave., Buffalo, N. Y.
KUEHNE, F. W., '79 .....19 Court St., Fort Wayne, Ind.

LAMB, J. MELVIN, M. D., '91.....906 G St., N. W., Washington, D. C.
LANDSBERG, A., '79..... ...156 Woodward Ave., Detroit, Mich.
LATHAM, MISS V., M. D., D. D. S., F. R. M. S., '88..... ....
....808 Morse Ave., Chicago, Ill.
LAWTON. EDWARD P., '88.....3 Linden Ave., Troy, N. Y.

Digitized by Google

LEIPPE, J. HARRY, '96.....Second and Franklin Sts., Reading, Pa.
LEWIS, MRS. KATHARINE B., '89.....
......"Elmstone," 656 Seventh St., Buffalo, N. Y.
LEWIS, IRA W., '87.....Dixon, Ill.
LINE, J. EDWARD, D. D. S., F. R. M. S., '82, 39 State St., Rochester, N. Y.
LOCKE, JOHN D., '93.....P. O. Box 129, Haverhill, N. Y.
LOMB, ADOLPH, '92.....48 Clinton Place, Rochester, N. Y.
LOMB, HENRY, '84.....48 Clinton Place, Rochester, N. Y.
LOOMIS, CHANDLER H., '87, Atlantic Dredging Co., 31 Pine St., N. Y. City.
LOVE, Prof. E. G., '91.....80 E. Fifty-fifth St., New York City.
LYON, HOWARD N., M. D., '84.....103 State St., Chicago, Ill.

MANTON, W. P., M. D., F. R. M. S., '85..32 W. Adams Ave., Detroit, Mich.
MARSHALL, COLLINS, M. D., '96... ..2507 Penn. Ave., Washington, D. C.
MARSHALL, WM., JR., '92..... ....Coudersport, Pa.
MASTERMAN, ELMER E. '97.....New London, Ohio.
MCCALLA, ALBERT, Ph. D., '80.....
.....414 Monadnock, Dearborn and Jackson Sts., Chicago, Ill.
MCKAY, JOSEPH, '84..... 259 Eighth St., Troy, N. Y.
MCKIM, Rev. HASLETT, '85 ..... Locust, Monmouth Co., N. J.
MEADER, LEE DOUGLASS, M. D., '96....914 E. McMillen St., Cincinnati, O.
MELLOR, CHAS. C., '85.....77 Fifth Ave., Pittsburg, Pa.
MERCER, A. CLIFFORD, M. D., F. R. M. S., '82.....
.....324 Montgomery St., Syracuse, N. Y.
MERCER, FREDERICK W., M. D., F. R. M. S., '83.....
.....2540 Prairie Ave., Chicago, Ill.
MERCER, W. F., '99,.....Biol. Laby., Ohio Univ., Athens, Ohio.
MILLER, JOHN A., Ph. D., F. R. M. S., '89..255 Ellicott St., Buffalo, N. Y.
MILNOR, CHAS. G., '86.....318 Highland Ave., Pittsburg, Pa.
MOBLEY, J. W., M. D., '98.....Milledgeville, Ga.
MOODY, ROBERT O., M. D., '91.....1204 Chapel St., New Haven, Conn.
MOORE, Prof. V. A., M. D., '87.....Cornell University, Ithaca, N. Y.
MURPHY, EUGENE E., M. D., '98.....Augusta, Ga.
MYERS, BURTON D., '97..... .....89 N. Tioga St., Ithaca, N. Y.

NUNN, RICHARD J., M. D., '83.....119½ York St., Savannah, Ga.

OERTEL, T. E., M. D., '92.....Med. Dept., Univ. of Ga., Augusta, Ga.
OHLER, W. H., '91 .....18 Locust St., Portland, Me.
OLSEN, ALFRED BERTHIER, M. D., '96....Sanitarium, Battle Creek, Mich.

PAQUIN, PAUL, M. D., '91..... .....3536 Olive St., St. Louis, Mo.
PARK, ROSWELL, A. M., M. D., '84.....510 Delaware Ave., Buffalo, N. Y.
PARKER, HORATIO N., '99.....24 Wendell St., Cambridge, Mass.
PATRICK, FRANK, Ph. D., '91.....601 Kansas Ave., Topeka, Kan.
PEASE, FRED N., '87.....Box 210, Altoona, Pa.
PENNOCK, ED., '79..... .....3609 Woodland Ave., Philadelphia, Pa.

Digitized by Google

PERRY, STUART H., ESQ., '90, Cor. Saginaw and Lawrence Sts., Pontiac, Mich.
PFLAUM, MAGNUS, ESQ., '91..... .....415 Grant St., Pittsburg, Pa.
PIWONKA, T., ESQ., '97..... 248 Superior St., Cleveland, Ohio.
POUND, ROSCOE, A. M., Ph. D., '98.....Lincoln, Neb.
PYBURN, GEORGE, M. D. '86..... .....1011 H St., Sacramento, Cal.

RANSOM, BRAYTON H., '99..... .....Bancroft, Neb.
REED, RAYMOND C., '79.....108 University Ave., Ithaca, N. Y.
REYBURN, ROBERT, M. D., '90.....2129 F St., N. W., Washington, D. C.
REYNOLDS, WILLIAM GEORGE, M. D., '97.....Woodbury, Conn.
RICE, FRANCIS SCOTT, '96, Cor. Third St. and Eastern Ave., Aspinwall, Pa.
RICHARDS, ELIAS, '99.....1722 Calhoun St., New Orleans, La.
ROBBINS, HENEY A., M. D., '91....1750 M St., N. W., Washington, D. C.

SAMPSON, ALLEN W., M. D., '96.....Pen Yan, N. Y.
SCHMITZ, HENRY, M. D., '96.....518 W. Chicago Ave., Chicago, Ill.
SCHONEY, L., M. D., '98...Lexington Ave. and 105th Sts., New York City.
SCHWERDTFEGER, LOUIS CHARLES, ESQ., '96.....Lincoln, Logan Co., Ill.
SEAMAN, WM. H., M. D., '86..1424 Eleventh St., N. W., Washington, D. C.
SECOR, JABIN A., '95.....Elmira, N. Y.
SEYMOUR, Prof. M. L. '85..... Chico, Cal.
SHEARER, J. B., '88.....809 Adams, St., Bay City, Mich.
SCHULTZ, CHAS. S., '82.....Hoboken, N. J.
SIEMON, RUDOLPH, '91.....22 E. Jefferson St., Fort Wayne, Ind.
SLOCUM, CHAS. E., Ph. D., M. D., '78.....Defiance, Ohio.
SMITH, J. C., '96.....131 Carondelet St., New Orleans, La.
SNYDER, JAMES B., D. D. S., '97.....Bryan, Ohio
STEDMAN, Prof. J. M., '95. .....Columbia, Mo.
STILLSON, J. O., A. M., M. D., '80.....445 N. Penna St. Indianapolis, Ind.
STOCKWELL, RODNEY R., '96..... .....Box 509, New Brighton, Pa.
STONEY, ROBERT J., JR., '96 .....P. O. Box 863, Pittsburg, Pa.
STOWELL, THOMAS B., A.M., Ph.D., '82, State Normal School, Potsdam, N.Y.
SUMMERS, Prof. H. E., '86.....Ames, Iowa

TAYLOR, GEO. C., '99.....Poydras, La.
THOMAS, ARTHUR H., '99..... 622 Locust St., Philadelphia, Pa.
THOMAS, PROF. MASON B., '90.....Wabash College, Crawfordsville, Ind.
TIMMINS, GEORGE, '96.....Syracuse, N. Y.
TWINING, FREDERICK E., '96..... ...1833 Mariposa St., Fresno, Cal.

VANDERPOEL, FRANK, M. E., '87.....191 Roseville Ave , Newark, N. J.
VEEDER, ANDREW T., M. D., '83..... .....
....Horne Office Building, Penn. Ave., Pittsburg, Pa.
VEEDER, M. A., M. D., '85.....Lock Box 1108, Lyons, N. Y.
VORCE, C. M., ESQ., F. R. M. S., '78.....5 Rouse Block, Cleveland, Ohio
VREDENBURGH, E. H., '84.....122 S. Fitzhugh St., Rochester, N. Y.

Digitized by Google

WALMSLEY, W. H., F. R. M. S., '78.....4248 Pine St., Philadelphia, Pa.
WARD, Prof. HENRY B., A. M., Ph. D., '87.....
.....University of Nebraska, Lincoln, Neb.
WEBER, Prof. HENRY A., Ph. D., '86....1342 Forsyth Ave., Columbus, O.
WEEKS, JOHN ROCKWELL, '99.....Power Block, Helena, Mont.
WEIGHTMAN, CHAS. H., '86..... 5859 Michigan Ave., Chicago, Ill.
WELCH, GEO. O., M. D., '91.....Box 416, Fergus Falls, Minn.
WELLINGTON, CHARLES, '99..... .....403 Pringle Ave., Jackson, Mich.
WENDE, ERNEST, M. D., '91.....471 Delaware Ave., Buffalo, N. Y.
WERUM, J. H., '93..... .....508 Adams St., Toledo, Ohio.
WHELPLEY, H. M., M. D., Ph. G., F. R. M. S., '90,.... .....
.....2342 Albion Place, St. Louis, Mo.
WHIPPLE, G. C., '99..... Mt. Prospect Laboratory, Brooklyn, N. Y.
WHITE, MOSES C., M. D., '85. .....214 Crown St., New Haven, Conn.
WHITLEY, JAMES D., M. D., '85 .....Petersburg, Ill.
WIARD, MARTIN S., '86.....21 Walnut St., New Britain, Conn.
WILLSON, LEONIDAS A., ESQ., '85.....112 Public Square, Cleveland, Ohio.
WILSON, MRS. MARY R., M. D., '95.....Ithaca, N. Y.
WOLCOTT, ROBERT HENRY, Prof., A. M., M. D., '98,.....
.....University of Nebraska, Lincoln, Neb.
WOODWARD, ANTHONY, '85.....306 W. 128th St., New York City.

YOUNG, AUGUSTUS A., M. D., 92..... .....
.....22 E. Miller St., Newark, Wayne Co., N. Y.
YZNAGA, JOSÉ M., ESQ., '90.....612 F St., N. W. Washington, D. C.

ZENTMAYER, FRANK, '91.....209 S. Eleventh St., Philadelphia, Pa.

HONORARY MEMBERS

COX, JACOB D., LL. D., F. R. M. S.....Oberlin, Ohio.
CRISP, FRANK, LL. B., B. A., F. R. M. S.....
... .5 Landsdowne Road, Nottingham Hill, London, England.
DALLINGER, REV. W. H., F. R. S., F. R. M. S.....
.....Ingleside, Lee, S. E., London, England.
HUDSON, REV. C. T., A. M., LL. D., F. R. M. S.....
.....6 Royal York Crescent, Clifton, Bristol, England.
MADDOX, R. L., M. D., Hon. F. R. M. S..... ..
....Greenbank, 45 Park Road, Portswood, Southampton, England.
SMITH, HAMILTON L., LL. D., F. R. M. S.....Geneva, N. Y.
WARD, R. H., M. A., M. D., F. R. M. S.. .....53 Fourth St., Troy, N. Y.

Digitized by Google

SUBSCRIBERS

PUBLIC LIBRARY.....Detroit, Mich, one copy
FIELD COLUMBIAN MUSEUM.....Chicago, Ill., one copy
COLUMBIA UNIVERSITY LIBRARY.....New York City, one copy
NEW YORK PUBLIC LIBRARY.....New York City, one copy
DULAU & Co.....37 Soho Square, London, England, two copies
CARNEGIE LIBRARY.....Pittsburg, Pa., one copy
SYRACUSE CENTRAL LIBRARY.....Syracuse, N. Y., one copy
ACADEMY OF NATURAL SCIENCES.....
.....Logan Square, Philadelphia, Pa., one copy
NEW YORK ACADEMY OF MEDICINE.....
.....17 W. Forty-third St., New York City, one copy
THE MISSOURI BOTANICAL GARDEN.....St. Louis, Mo., one copy
SCIENTIFIC LIBRARY....U. S. Patent Office, Washington, D. C., one copy
N. Y. STATE VETERINARY COLLEGE.....
.....Cornell University, Ithaca, N. Y., one copy
U. S. MEDICAL MUSEUM AND LIBRARY .....
.....Surgeon General's Office, Washington, D. C., one copy
R. FRIEDLAENDER & SOHN..Berlin, N. W., Carlstr. 11, Germany, one copy
NEW YORK STATE LIBRARY.....Serial Section. Albany, N. Y., one copy
BOSTON SOCIETY OF NATURAL HISTORY .....
....Berkeley St., Boston, Mass., one copy
DR. JOS. H. LINSLEY.....
.....Director of Hygienic Laboratory, Burlington, Vt., one copy
LIBRARY OF THE OHIO STATE UNIVERSITY....Columbus, Ohio, one copy
LABORATORY OF HISTOLOGY AND EMBRYOLOGY.....
.....University of Minnesota, Minneapolis, Minn., one copy
LIBRARY OF THE UNIVERSITY OF NEBRASKA....Lincoln, Neb., one copy
JOHN CRERAR LIBRARY.....Chicago, Ill., one copy
LIBRARY OF THE UNIVERSITY OF ILLINOIS....Champaign, Ill., one copy

Digitized by Google

Digitized by Google

WE MANUFACTURE....

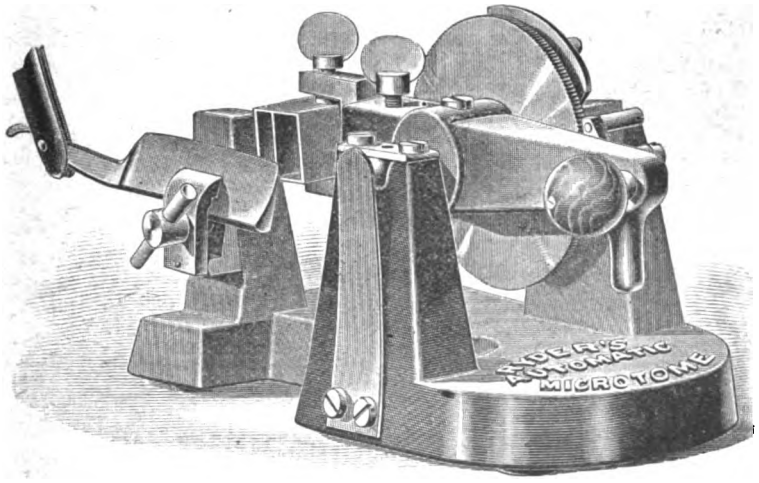
Microscopes

MECHANICAL ACCESSORIES

THE FAMOUS....

RYDER MICROTOME

MICROMETER RULINGS MADE TO ORDER



ILLUSTRATED CATALOGUE ON APPLICATION

JOSEPH ZENTMAYER

Established 1835. No. 209 So. 11th St., Philadelphia.

Digitized by Google

W. WATSON & SONS,

313 High Holborn, London, England.

New Objectives, Condensers, Etc. Watson's Holoscopic Objectives.

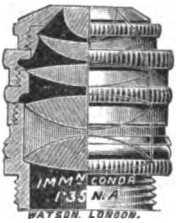
A Series of Lenses of entirely new construction, corrected for sphercial aberration in a wonderfully perfect manner. Unsurpassed for working qualities.

24 mm. (1 in.) N.A. 0.30.....$ 9.75
12 mm. (½ in.) N.A. 0.45.....$12.25
12 mm. (½ in.) N.A. 0.65.....$17.25
6 mm. (¼ in.) N.A. 0.74 .....$12.25
Oil Immersion
3 mm. (⅛ in.) N.A. 1.30..... .....$39.00
2 mm. (1-12 in.) N.A. 1.35 .....$39.00

WATSON'S HOLOSCOPIC EYEPIECES

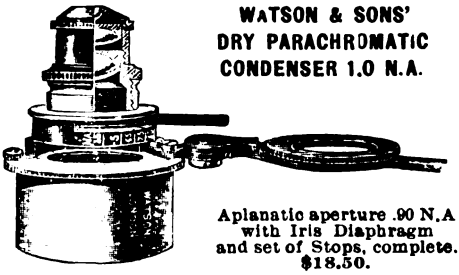
For use with either Apochromatic or Achromatic Objectives, having an adjustment to render them over or under corrected magnifying powers.
For 6 in tube length, 7, 10, 14 and 20 diameters.
For 10 in. tube length, 5, 7, 10, 14 and 20 diameters.

Price—Student's Pattern..... ..... $4.50
Best Capped Pattern 5.50



WATSON'S OIL-IMMERSION SUBSTAGE CONDENSER.

Watson's Oil-Immersion Condenser has a total N.A. exceeding 1.30, and an aplanatic aperture exceeding 1.25 N.A. It is undoubtedly the best Condenser yet produced for high-power work.
Optical part only..... ..... $24.50
Completely fitted with Iris Diaphragm and Set of Stops for dark grounds and oblique illumination..... $32.00



WATSON & SONS' DRY PARACHROMATIC CONDENSER 1.0 N.A.

Aplanatic aperture .90 N.A., with Iris Diaphragm and set of Stops, complete. $18.50.

Bacteriological Outfits.
Microtomes of every description.
Merck's Stains and Preparations.
Field Botany Apparatus.
Field Geology Apparatus.
Entomological Apparatus.
Physiological Models.
Botanical Models.
Prepared Skeletons.
Dissected Preparations.
Metamorphoses Series.

Full particulars of everything of the latest and best for Microscopical work are contained in Watson's Illustrated Catalogue, No. 6.

MICROSCOPIC OBJECTS.

Watson & Sons hold a stock of 40,000 specimens, all of the highest class forming undoubtedly the FINEST COLLECTION IN THE WORLD. Full classified List No. 3 forwarded, post-free, on application to

W. WATSON & SONS,

(ESTABLISHED 1837,

OPTICIANS TO H. M. GOVERNMENT,

313 HIGH HOLBORN, LONDON, W.C.

And 78 Swanston St., Melbourne, Australia.

Awarded 39 Gold and other Medals at International Exhibitions, including 5 Highest Awards at the World's Fair, Chicago, 1893, 2 Gold Medals, Paris Universal Exhibition, 1889, &c., &c.

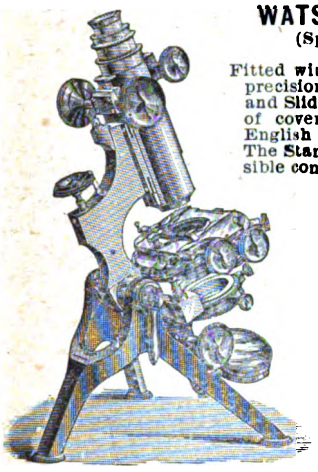
Digitized by Google

W. WATSON & SONS,

OPTICIANS TO H.M. GOVERNMENT.
ESTABLISHED 1837.

313 HIGH HOLBORN, LONDON, ENGLAND.

Manufacturers of MICROSCOPES, OBJECTIVES, and Accessories of Finest Quality only.
Sole Manufacturers of the well-known "Van Heurck" and "Edinburgh Student's" and "Fram" Microscopes.



WATSON'S VAN HEURCK MICROSCOPE

(Specially designed for high-power work and Photomicrography).

Fitted with Fine Adjustments of utmost sensitiveness and precision, not liable to derangement by wear. Has Rackwork and Sliding Draw-tubes to correct objectives for thickness of cover glass. Can be used with either Continental or English Objectives. Has Fine Adjustment to Substage. The Stand is specially designed to afford the greatest possible convenience for manipulation.

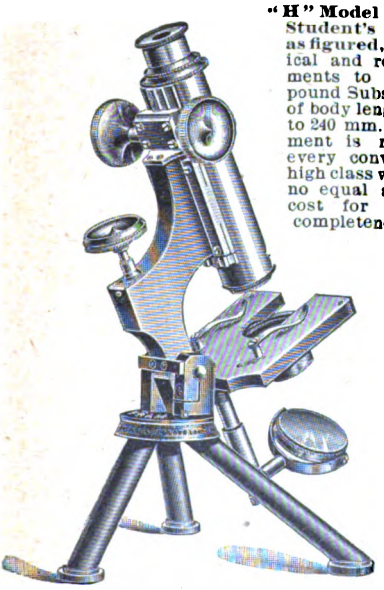
PRICE:—As figured (but without centering screws or divisions to Stage) with 1 Eyepiece ..... $ 91.00
New Model, with complete rotation to Stage $103.00

WATSON & SONS' EDINBURGH STUDENT'S MICROSCOPE

Made in four models, on both Horseshoe and Tripod foot,

Price, $15.50.

"H" TRIPOD. Edinburgh Student's Mic'oscope



"H" Model Edinburgh Student's Microscope as figured, has mechanical and rotary movements to Stage, compound Substage. Range of body length from 152 to 240 mm. This instrument is replete with every convenience for high class work and has no equal at the same cost for quality and completeness. Price, with one Eyepiece, $46.50

"H" Stand, with 2 Eyepieces, 1 in. and 1-6 in. Objectives, Abbe Illr. with Iris diaphragm and set of Stops, in mahogany case $73.25

Watson's "FRAM" Microscope

A Highest Class Microscope at a Very Moderate Cost.

Coarse Adjustment—Watson's diagonal rack and pinion.
Fine Adjustment—Watson's lever form.
Tripod Foot, with 7-in. spread.
Stage—Nelson's Horseshoe pattern, 3⅛ by 3¼ in
Body Length—152 mm. With draw-tube extended 250 mm. Objective thread at lower end of draw-tube.
Fittings of Universal size throughout.
Under Fitting arranged to turn out from optic axis when desired.

PRICES.

Set X. "Fram" Microscope, with one Eyepiece, Watson's Parachromatic 1-6 in. and choice of 1 in., ¼ in. or ⅔ in., complete in Mahogany Case. $33.00
Set XI. Complete as per *Set X*, with the addition of Abbe Illuminator having Iris Diaphragm and extra eyepiece $40.25
Set XI. For Bacteriology, complete as per *Set X* with addition of 1-12 in Oil Immersion Objective, and Dust-Proof Triple Nosepiece $68.50

Catalogue No. 2 gives full particulars of all the above, mailed post free.

Digitized by Google

MICROSCOPES

Accessory Apparatus and Laboratory Supplies.....

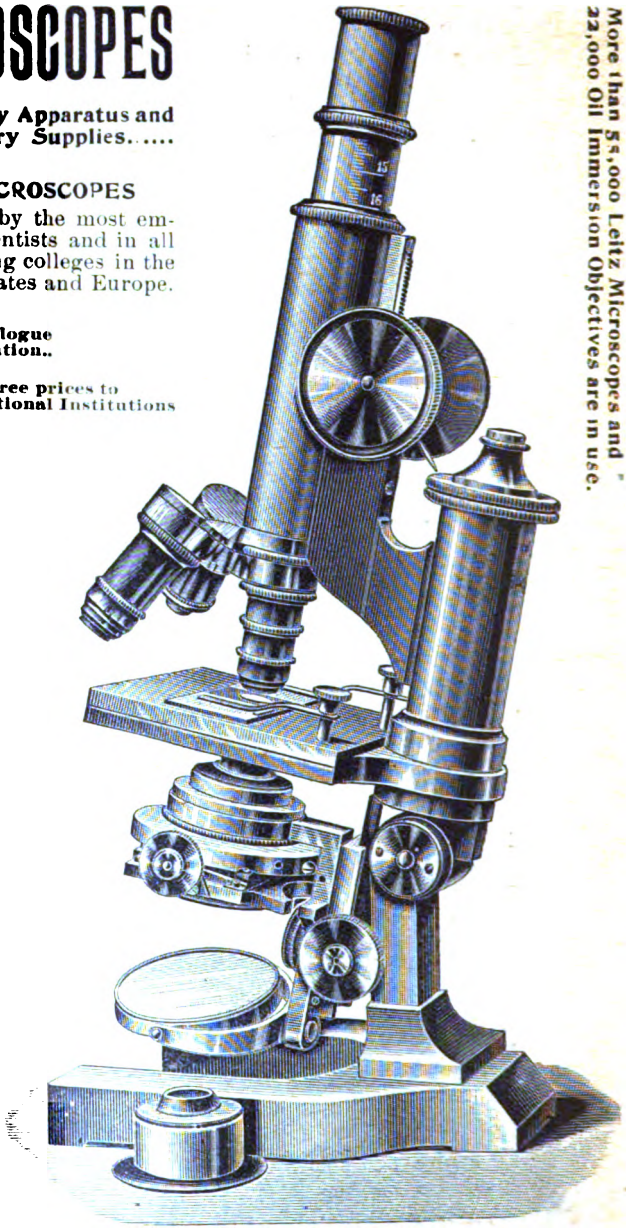
LEITZ'S MICROSCOPES

are used by the most eminent scientists and in all the leading colleges in the United States and Europe.

Complete Catalogue sent on application..

Duty free prices to Educational Institutions

More than 55,000 Leitz Microscopes and 22,000 Oil Immersion Objectives are in use.



E. LEITZ

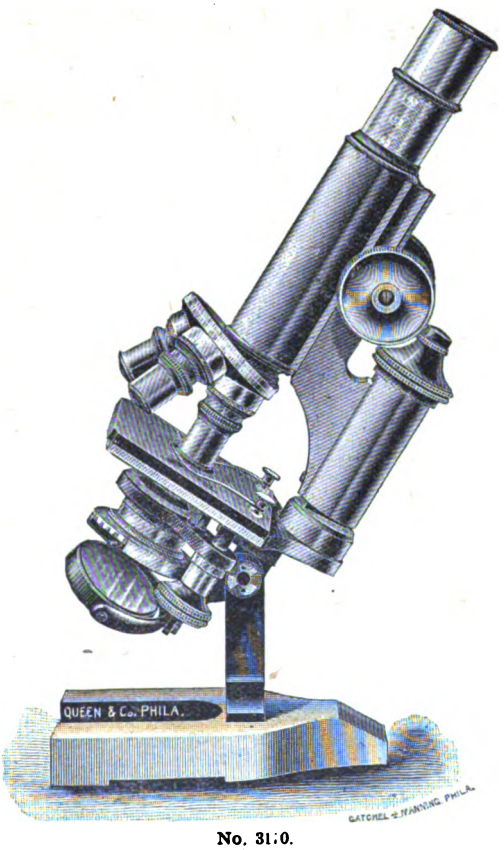
NEW YORK
411 W. 59th Street.

CHICAGO
639 W. Congress St.

Digitized by Google

THE QUEEN CONTINENTAL No. II MICROSCOPE

Our Standard Instrument for all Lines of Work



No. 3170.

We fit this Stand in the following four outfits:

PRICE LIST.

3167. Queen Continental Stand No. II with screw motion to sub-stage) ⅔ inch objective of 40° angle, two eye pieces, in polished case $50 00

3168. Outfit No. 3167, with addition of double nose piece..... ..... 54 50

3169. Outfit No. 3168, with addition of sub-stage condenser of about 1 00 N. A., with iris diaphragm..... $64 40

3170. Outfit No. 3170, with addition of 1½ inch Homo. immersion objective of 1.35 N. A., *Abbe* condenser of 1.20 N. A., and *triple* nose piece..... 95 00

Colleges please write for discounts. **Catalogues sent on request.**

QUEEN & CO., (Inc.) Optical and Scieutific Inst. Works,

NEW YORK: 59 Fifth Ave. **1010 Chestnut Street PHILADELPHIA, U. S. A.**

Digitized by Google

CRAMER'S....

PHOTO • DRY • PLATES

BANNER AND CROWN

Are Unexcelled for Quality
Rapidity and Uniformity...

CRAMER'S

Isochromatic Plates

Instantaneous
Medium and
Slow . . . . .

ARE HIGHLY SENSITIVE TO YELLOW AND ORANGE, AND ARE UNDOUBTEDLY THE BEST COLOR PLATES ON THE MARKET

For Sale by all Dealers in Photo Supplies.

G. CRAMER DRY PLATE CO.

NEW YORK DEPOT,
32 E. 10th St . . .

. . St. Louis, Mo.

Mention the Society in writing to advertisers.

Digitized by Google

Webster's International Dictionary

A Dictionary of English, Geography, Biography, Fiction, Etc.

IT EXCELS in the ease with which the eye finds the word sought; in accuracy of definition; in effective methods of indicating pronunciation; in terse and comprehensive statements of facts and in practical use as a working dictionary.

HON. D. J. BREWER, Justice of U. S. Supreme Court, says:

"I commend it to all as the one great standard authority."

The **International** has been warmly commended by members of the **United States Supreme Court,** by all the **State Supreme Courts,** by **all State Superintendents of Schools,** and by eminent **authors** and **educators** almost without number. It is recognized as the standard authority by the **United States Government Printing Office,** and is the standard to which nearly all **schoolbooks** adhere.

. . . The Best for Practical Use . . .

BECAUSE words are given in their correct alphabetical places, each one beginning a paragraph.

BECAUSE the pronunciation is indicated by the ordinary diacritically marked letters used in the schoolbooks.

BECAUSE the etymologies are full, and the different meanings are given in the order of their development.

BECAUSE the definitions are clear, explicit, and full, and each is contained in a separate paragraph.

BECAUSE excellence of quality rather than superfluity of quantity characterizes its every department.

Also WEBSTER'S COLLEGIATE DICTIONARY
with a Scottish Glossary, etc.

"First class in quality, second class in size."—*Nicholas Murray Butler.*

Specimen pages, etc., of both books sent on application.

G. & C. MERRIAM CO., **Publishers, Springfield, Mass.**

Digitized by Google

SPENCER

Spencer Marvelous Objectives
Spencer Unique Modern Stands
On request these instruments will be gladly sent for comparison with those of any other manufacture.

SIMEON TRENNER,
Laboratory and Microscopical Supplies.
Sole Phila., Washington and Balto Agent.
132 So. 11th St., - Phila.

EDWARD PENNOCK, OPTICIAN, IMPORTER

3609 Woodland Avenue (Opp. Univ. of Penna.) PHILADELPHIA

My life-long Specialty is in fine Microscopes and Accessories, . . . New and Second-hand . . .

SEND FOR SPECIAL BARGAIN LIST. Importation of Zeiss Microscopes, Zimmermann-Minot Microtomes and other foreign instruments made at low rates. I CAN ASSURE ESPECIALLY PROMPT EXECUTION OF IMPORT ORDERS, and can refer to Professors in some of the leading Universities of the country, to whose especial satisfaction *in respect to price and promptness*, I have executed such orders.

SECOND-HAND : : :
Microscopes,
Objectives,
Accessories, Etc.

Cameras, Kodaks,
Photographic Objectives,
Accessories, New and
Second-hand.

A New Specialty **WATER-WHITE CANADA BALSAM** Almost absolutely colorless, in fact apochromatic

Sample ½ ounce bottle 25c.

Mention the Society in writing to advertisers.

Digitized by Google

Practical Methods in... MICROSCOPY

By CHARLES H. CLARK, A.M., D.Sc.

Fellow of the Royal Microscopical Society (London).

THIS is a manual of microscopical technique sufficiently elementary for the beginner, and at the same time sufficiently advanced to give the college student an easy understanding of the general methods of microscopical manipulation. It contains all that any student of microscopy needs until his studies call him to advanced research in special fields, in which case treatises on his specialty must give him the needed guidance.

NATURE, *London:* It is in almost every way a well arranged and well written work and will be practically a boon to whom experienced advice is inaccessible.

CONTENTS:—*I. Light and the Microscope. II. Some Accessories for Advanced Work. III. Polarized Light and the Polarizer. IV. Instructive Practice in Manipulation. V. Methods of Studying Fresh Objects. VI. Mounting Objects for the Microscope. VII. Practice Mounting. VIII. Botanical Sections. IX. Section of Animal Tissues. X. Chemical Crystals. XI. Rock Sections by Simple Means. XII. The Study of Bacteria. XIII. The Study of Bacteria; Culture Methods. XIV. Photo-Micrography. Appendix. Useful Formulas. Index.*

Illustrated with 53 cuts and engravings and 17 photo-micrographs.
Cloth. 277 Pages. Price $1.60.

D. C. HEATH & CO., Publishers, -:- Boston, New York, Chicago.

EIMER & AMEND,

205-211 Third Avenue **New York.**

AGENTS FOR . . . .

Zeiss & Spencer's Microscopes

Grubler's Stains and Chemical Preparations

Schleicher & Schull's Filters

Bacteriological Glassware

All Necessary Microscopical Accessories

COMPLETE LABORATORY OUTFITS

☞ Glassblowing done on the premises by most experienced workmen. ☜

Digitized by Google

Leitz Microscopes **STAUDINGER ANALYTICAL BALANCES**

Clinical Apparatus **INCUBATORS and STERILIZERS**

"Non-Corrosive Culture" Tubes **PETRI DISHES**

... DUTY FREE IMPORTATIONS ...

All laboratory directors are more or less interested in the above lines. THEY ARE MY SPECIALTIES. My interest therefore centers in them also. If our interests concide it will certainly pay you to write me for further information and circulars.

ARTHUR H. THOMAS.

Importer and Manufacturer's Agent.

A large collection of European Apparatus Catalogues facilitates quotations on foreign orders.

622 Locust St. (So. Wash. Sq.),
PHILADELPHIA, U. S. A.

CONCILIUM BIBLIOGRAPHICUM,

ZÜRICH, SWITZERLAND.

An International Bibliographical Bureau established in accordance with a unanimous vote of the Third International Zoological Congress under the control of an International Commission.

The Bureau appeals to biologists to see that their publications reach some Zürich Library, or are sent direct to the Bureau.

THE BUREAU ISSUES THE FOLLOWING OF INTEREST TO EVERY MICROSCOPIST

CATALOG CARDS OF RECENT LITERATURE

IN ZOOLOGY AND ALLIED TOPICS.

Subscriptions accepted for the full set or any part as desired.

CONSPECTUS METHODICUS | ZOOLOGICUS ANATOMICUS
BIBLIOGRAPHIA PHYSIOLOGIA.

For information and prices address . . Concilium Bibliographicum, Zürich, Switzerland.

Digitized by Google

THIS and the previous report of the American Microscopical Society, was printed in the West, by the HUNTER-WOODRUFF PRINTING CO., LINCOLN, NEBR. Members can form a pretty good idea of the character of Printing turned out by Western houses by making a comparison with previous Reports. In fact, we invite comparison. In addition to Book and Catalog Printing, we do Commercial Printing in all its branches, and solicit correspondence concerning anything in the line of General Printing.

HUNTER-WOODRUFF PRINTING CO.,
(INCORPORATED)

LINCOLN, NEBRASKA.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Members should bear in mind that they owe not only their thanks, but also their patronage to the advertisers who contribute thus toward the publication of the volume.

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

UNIVERSITY OF MICHIGAN
[redacted]
3 9015 03880 3641

BOUND

FEB 8 1940

UNIV. OF MICH.
LIBRARY

Digitized by Google

Digitized by Google